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The F. D. McMaster Animal Health Laboratory.

In view of the recent completion of the erection and equipment of the above Laboratory, it has been thought that the following brief description of its more important features will be of interest.—ED.

In a previous issue (this *Journal*, Vol. 2, Nov., 1929, p. 193), an account was given of the magnificent gift of £20,000 which Mr. F. D. McMaster of "Dalkeith" made to the Council for the purpose of erecting an animal health laboratory in New South Wales. A photograph of the interesting deed of gift in which he expressed his wishes in connexion with the gift was also given in that issue.

Mr. McMaster is a representative of the third generation of McMasters who have successfully followed pastoral pursuits in Australia, and for many years "Dalkeith" station, where the famous stud of that name is located, has been owned by the family. The association of the name McMaster with a Laboratory which is to concentrate primarily on problems relating to sheep is therefore particularly appropriate.

The erection of the building and of its permanent fittings was completed quite recently, and the staff it will accommodate is now moving into it. Dr. I. Clunies Ross has been placed in charge. The work already in progress in the building relates to internal parasites of sheep (stomach worms, lung worms, &c.), including nutritional aspects of this problem, caseous lymphadenitis, contagious mammitis, certain aspects of footrot of sheep, and other problems of a more minor nature.

The Laboratory is located within the grounds of the University of Sydney alongside the buildings of the existing Veterinary Department of the University and facing Parramatta-road. It is illustrated on Plate 1 (facing page 250).

As to its design, suggestions were obtained from a number of Australian veterinarians and other scientific workers and, after due consideration of these, the various requirements finally decided upon were passed on to the New South Wales branch of the Commonwealth Department of Works and Railways which supervised the erection, on behalf of the Council, through the local Director of Works, Mr. C. H. U. Todd. The actual design was the work of Mr. E. H. Henderson, the Principal Designing Architect, Central Office (Department of Works and Railways), Canberra, F.C.T. The builders were Messrs. Beat Bros., of Sydney.

The building is rectangular in shape, the maximum outside dimensions being 155 feet by 43 feet. At the present time, it is two-storied, but the walls and foundations are sufficient to take another floor should further accommodation become desirable in the future. The structure is of brick, with a stone foundation and base, and with a terra cotta tiled roof. The room partitions do not carry any appreciable weight, and thus can easily be moved

should later developments indicate that a readjustment of rooms would be helpful to the work. In all, 36 individual rooms are now contained in the Laboratory.

The building faces north and, as far as possible, all laboratories in which bacteriological or other microscopic work will be done are situated on the southern side, thus having no direct sunlight. The windows, which occur at 10 feet intervals from centre to centre, are admirably fitted for microscopic work, as the bottom half of each consists of one undivided sheet of glass.

Ground Floor.—On the ground floor, there are at the east end of the building, on the north side, a scullery and kitchen, all media preparation and sterilization of glassware for the laboratories being centralized here. On the north side are situated a media store, a refrigeration room for the preservation of culture media, &c., administrative offices, and a bulk store.

On the southern side of the ground floor, there is first a large post-mortem room, fitted with sliding doors, white tiled throughout, and provided with a shadowless operating lamp. The room is specially designed and equipped for the conduct of detailed post-mortem examinations, and from it a hand lift is provided to take the organs and tissues of animals to the first floor, where examination of many of them is carried out in the parasitological laboratories. Next to the post-mortem room on the southern side is a preparation room, in which all embedding and sectioning of pathological material is carried out. On this side also, there is a series of four pathological laboratories, each capable of accommodating two research workers. These laboratories have standard fittings throughout, with very complete drawer and cupboard accommodation, special provision being made in the way of fume chambers, so that no objectionable gases escape into the laboratories. All benches are covered with plate glass, which facilitates keeping them in aseptic condition, and all gas and electrical fittings have front control, so that the worker does not have to endanger delicate equipment by stretching across the bench. Another feature of the laboratories is the installation of counterbalanced bench lights, which are capable of easy adjustment at any height, in any position, either for illuminating microscopes or for any other purpose.

Also on the ground floor on the southern side is a hot room, in which stocks of bacteriological cultures can be maintained at an even temperature of 37° C. without recourse to incubator equipment. This room is cork insulated throughout and fitted with an extremely heavy padded door. The dark room, which is on the ground floor, is also provided with every convenience, including a cascade washer, and a print drying cupboard, which is fitted with an exhaust fan and a heating unit.

First Floor.—On the first floor and at the western end of the building, there is another bulk store and a large laboratory fitted with dark blinds, and provided with a projection lantern. Over the central hall, a library 26 feet by 12 ft. 6 in. is situated, lit by a large semi-circular window.

The whole of the eastern end of the southern side of this floor is occupied by three parasitological laboratories, these having essentially the same fittings as the bacteriological laboratories, except that fume cupboards are not required. In the parasitological laboratory at the extreme eastern end of the building, a large island bench is provided for the accommodation of heavy centrifuges and other bulky equipment. It is intended that all gross examination of parasitological material will be restricted to this laboratory. Opening off it there is an insulated warm room, in which parasites may be maintained during winter at summer temperatures, by means of suitable radiator equipment. Owing to the installation of vita-glass windows in

this room, it will also be possible to maintain the parasites under conditions of natural sunlight. It is thus expected that the provision of this warm room, which is of a unique character, will greatly facilitate the conduct of parasitological investigations during the winter months.

On the northern side of the top floor, provision is made for a bio-chemical staff, there being ample laboratory accommodation, a dark room and a balance room. At the present time, these rooms are not completely fitted, but all essential services are provided, so that the equipment can be completed at any future date at little cost and inconvenience.

In the existing buildings of the Veterinary School, ample accommodation for small experimental animals is available, while outside there are numerous pens for the housing of experimental sheep and cattle.

General.—The closest contact is being maintained with the University of Sydney regarding the work of the Laboratory. For example, the Laboratory will be under the general control of an Advisory Committee, of which the Dean of the University Faculty of Veterinary Science (Professor J. D. Stewart) will be a member. A part of the equipment of the Veterinary School is also being transferred to the Laboratory, which will accommodate the researches not only of the Council, but of the School as well. Already, Mr. H. R. Carne, B.V.Sc., Lecturer in Veterinary Pathology and Bacteriology at the School, and who is controlling bacteriological and pathological researches in the Laboratory on behalf of the Council, has been provided with ample accommodation for that work.

To sum up, the McMaster Laboratory is a most valuable and necessary addition to the resources of the Council's Division of Animal Health. The latter will now be able more fully to play its part as a member of the small team of research workers and organizations engaged on investigations of those problems of the Australian pastoral industry which must be solved if the industry is to continue in anything approaching a satisfactory condition from the economic point of view.

The Council is deeply grateful to Mr. McMaster for his magnificent gift.

The Rate of Growth of a South Australian Merino Fleece.

By K. M. Fraser, B.Agr.Sc.

Mr. Fraser is an agronomist who has been appointed in connexion with the mineral deficiency of pasture investigations being carried out at the Waite Agricultural Research Institute as a co-operative enterprise of the Institute, the Council for Scientific and Industrial Research, and the Empire Marketing Board. His main work has been directed to the management of the sheep used in these investigations, and to a study of the effects of various forms of fertilizers on the growth and development of natural pastures in relation to their grazing value. The short report that follows gives the results of fifteen monthly measurements of the wool staples on ten merino sheep of uniform age, weight, and quality at a fixed point on the sheep. The results show that the growth of the staple is uniform, notwithstanding the fact that the sheep gain and lose considerable body weight according to the quality and quantity of the natural pasture available.—Ed.

Introduction.

The rate of growth of wool has been the subject of numerous investigations, but the results obtained have been somewhat contradictory.

Duerden(2), in his paper on the absence of uniformity in the growth of the merino fleece, has shown that the changes of thickness of the fibre represent changes in the vigour of growth of the animal. He presumes that rate of growth in length of the fibre will also vary according to the condition of the sheep, but acknowledges the difficulty of obtaining conclusive methods of determining this. In a later paper(3) on the zoology of the fleece of the sheep, he states that fibre growth is continuous and practically uniform, though there appears to be some evidence that the growth rate is slightly more rapid after shearing than before.

Hardy and Tennyson(5) came to the conclusion that the growth rate, both in fibre length and in fibre thickness, varied throughout the year. In these investigations Hardy and Tennyson employed a clipping technique, though a system of tying locks each month was tried.

More recently, Norris and Claassens(6), in their study of crimp in wool, carried out measurements on fibres cut at monthly intervals for a period of 31 months, from a South African merino. They found that fibre thickness showed the influence of seasonal conditions, while increase in fibre length proceeded at a uniform rate throughout the whole life of the sheep.

Hackedorn and Sotola(4), after four years' work on the rate of wool growth, found that the average length-growth during the summer season and winter season was quite uniform. They state also that the length-growth in the first year is practically the same as the length-growth in the fourth year.

Burns(1) states that the monthly growth of Ramboullet ewes was remarkably uniform throughout the year and in the four different years. He found that staple length measurements, as a method of obtaining the monthly growth rate, were somewhat unreliable. He used a clipping method which involved the measurement of individual fibres.

Zorn(8) concluded from his work that the rate of growth of wool during the six months following shearing was considerably greater than the rate of growth during the subsequent six-monthly period.

While this paper was in the press, an article by Duerden and Marè(9) has appeared giving results of investigations in South Africa on this subject. They found that the average monthly growth during each of two complete years was practically the same.

Work at Adelaide.

Investigations were commenced in November, 1929, at the Waite Agricultural Research Institute to determine the rate of growth of the fleece of merino sheep grazed on "natural" pasture throughout the year. The method used was the periodic measurement of the mean length of adjacent staples, at fixed points on the scapula, of ten merino sheep.

The judgment of the breeder, the buyer, and wool expert is made on the staple form. Their judgment of length of fleece is based on staple length rather than on the length of individual fibres. The staple is the unit in wool practice and commerce.

In the present study, the problem has been approached with the staple as the unit, which reflects the behaviour of the fleece as a whole. The method has the advantage that it is rapid, and can be carried out on the animal itself without resorting to the laborious technique involved in clipping methods.

The rate of elongation of the staple is not necessarily the same thing as the rate of growth of the individual fibres composing the staple. Roberts(7) stressed this point, and states that, although it is possible to obtain a mean value for the length of fibres composing a lock, the length of the lock, when measured as such, will not necessarily agree.

Material and Methods.

The method adopted was the monthly measurement of adjacent staples at fixed points on the near and off shoulders of ten merino sheep. As the experiment was essentially a statistical examination, care was exercised in the selection of the sheep, to secure uniformity in fleece weight and quality of wool. A station line of 120 merino four-tooth wethers was obtained from Nalpa Station, and a selection made to conform to the following points:—

(*a*) Fleece weight to be between 4 and 5 kilos.
(*b*) Quality of wool, 60's.
(*c*) Live weight to be between 40 and 50 kilogrammes.

Only twenty animals complied with the above desiderata, and the ten sheep used for the investigation were taken at random from the twenty, by letting the sheep run through a race.

Throughout the investigation, the sheep were grazed on natural pasture, and monthly measurements of staple length were carried out. Five measurements were made on the near and off sides of each sheep, making 100 measurements in all. The sheep were machine-shorn on 26th September, 1929, and, as the experiment was not commenced until 26th November, the first observation recorded comprises the length of wool left on the sheep at shearing, plus the growth from shearing to 26th November.

Technique of Measurement.

The measurements were made at a fixed point on the near and off shoulders of the sheep immediately above the acromion process at the inferior end of the spine of the scapula. For the measurements of staple length a narrow steel rule, graduated in millimetres and fitted with a brass slider, was used.

The method adopted in making the measurements consisted of laying the animal flat on its side and opening up the wool so that the acromion process could be located. The zero end of the rule was placed on this point and held there while five adjacent locks were in turn drawn firmly up the rule and the slider pushed down to meet the tip of the lock. The rule being then withdrawn, the observations were made from the position of the slider, and recorded. On the completion of the near-side measurements, the sheep was rolled over so that the off-side readings could be taken.

In all cases the measurements were carried out by the writer, so that the personal factor in technique and measurement was constant.

Results.

After the measurements were completed, the sheep were weighed. The live-weight records are shown in Figure 2, Plate 2. Occasionally, owing to wet weather, the readings could not be taken at absolutely fixed intervals of 28 days. In a few cases the interval between measurements was 29 days, and in one case 30 days.

TABLE I.—MEAN STAPLE LENGTH AT MONTHLY INTERVALS FROM 26TH NOVEMBER, 1929, TO 21ST JANUARY, 1931.

Date.	Month.	Mean mm.	Standard Error mm.	Standard Error %
November 26	0	30.26	±0.67	2.2
December 24	1	39.90	±1.07	2.6
January 21	2	50.54	±1.00	1.9
February 18	3	58.78	±1.28	2.2
March 18	4	66.76	±1.21	1.8
April 16	5	74.09	±1.57	2.1
May 14	6	82.72	±1.74	2.1
June 11	7	93.14	±2.14	2.3
July 10	8	101.50	±1.92	1.9
August 6	9	112.03	±1.69	1.5
September 3	10	118.05	±2.62	2.2
September 30	11	127.83	±2.46	1.9
October 30	12	137.74	±2.95	2.1
November 26	13	144.46	±2.99	2.1
December 24	14	153.63	±2.74	1.8
January 21	15	163.68	±2.91	1.8

The means were subjected to statistical examination and plotted in Fig. 1, Pl. 2, along with the calculated line obtained by the method of Least Squares. The observed line was tested for goodness of fit by the calculation of χ^2. The value obtained was .2030, which gives odds of more than 1,000,000 to 1 for such deviations being due to chance alone. The results obtained, therefore, could be expressed by a straight line. Under the conditions of the test, therefore, the rate of growth of the staple was uniform.

A consideration of the live-weight data (Figure 2) shows that the feeding value of pasture is reflected in the live weight of the animals. This graph is substantially that obtained in other experimental work with sheep at the Waite Institute, and may be regarded as the normal seasonal fluctuation in the live weight of sheep under "natural" pasture conditions. It should be noted that, though the sheep were grazed on

"natural" pasture without supplementary feeding, they were never short of feed. The nutritive value of the feed varied with the season, but no actual shortage was experienced throughout the period of the test.

The climatic conditions of the district are those of winter rainfall and summer drought. From late autumn to spring the "natural" pastures, which consist largely of *Danthonia penicillata* with an admixture of annual grasses and clovers and herbaceous annuals, are green, palatable, and nutritious, and sheep make rapid gains in weight. With the cessation of seasonal rains in September, and rising air and soil temperatures, there is a flush of vegetation, which rapidly dries out, and on this dried pasture the sheep subsist during the summer months. Towards autumn, the quantity of herbage available for grazing declines, together with the nutritive value, and sheep lose a considerable portion of the gains they made during the previous spring. With the seasonal break in the weather, green herbage becomes available once more, and the rate of growth of the sheep (as reflected in live weight) again increases (*vide* Figure 2).

It is probable, in the light of work done elsewhere and of general experience with South Australian wool samples, that the principal effect of the normal autumn diminution of the nutritive value of the natural pastures, indicated by live weights, is reflected in the thickness of the wool fibre and not in the staple length.

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The Relation between Durability and the Extractives of the Cypress Pines (*Callitris* spp.).

By I. W. Dadswell, M.Sc., and H. E. Dadswell, M.Sc.

Summary.

The reason for the durability of the cypress pines (*Callitris* spp.) has been investigated, using wood from *C. glauca*, *C. calcarata* and *C. intratropica*.

The volatile oil present in these woods, the alcohol soluble material, and the aqueous extracts have been isolated.

From the volatile oils and the alcoholic extracts, several specific fractions have been isolated, namely gaujol, a sweet-smelling oil, a liquid acid, a non-volatile viscous oil, an ether soluble resinous material, and an ether insoluble resinous material.

These fractions, together with the hot and cold aqueous extracts from *C. glauca* and *C. calcarata*, have been used in laboratory toxicity tests towards the fungus *Fomes annosus*, and it has been shown that (i) the liquid acid is most toxic, killing at a concentration of 0·015 per cent., and (ii) that the aqueous extracts inhibit the growth of this fungus.

The same fractions have been used in laboratory resistance tests towards termites (*Eutermes exitiosus*), and it has been shown that, of the various fractions tested, the volatile acid and the ether soluble resin were the most distasteful.

The possible practical utilization of the results obtained have been discussed, and it has been pointed out that these results have led to an interesting series of experiments which, it is hoped, will prove of economic value.

1. Introduction.

While Nature has endowed mankind with many varieties of durable woods, their number in comparison to the non-durable species is not large. Moreover, their value was soon recognized and the available supplies have been rapidly diminishing throughout the world.

It is a matter of importance, therefore, to determine what exactly is responsible for such durability. Numerous workers (1) in this field have shown that there is a definite relationship between durability and the chemical composition of wood, and further that the extractives or soluble materials present in the timber are responsible for such durability. The relative resistances of woods to destructive fungi have, for example, been demonstrated by employing the isolated aqueous extracts in laboratory toxicity tests towards these fungi (2, 3, 4). In this manner valuable information has been obtained with respect to the relative resistance of numerous durable and supposedly durable species.

Numerous chemical compounds, mainly of an organic nature, are present in the extractives that can be isolated from any particular species, and the resistant properties may be due to one or even more of these. It is possible too that one compound may be toxic to fungi and not repellent to termites (white ants) or vice versa. Further examination of any extractives isolated thus becomes necessary.

In nature, such organic compounds as are found in the tree are synthesized therein, and it should be possible for the chemist, once he has discovered their chemical compositions and studied their properties, to synthesize identical or similar compounds in the laboratory, although, of course, such a synthesis may not be commercially feasible. Alternatively, it may be that a related but commonly-occurring material would be effective if used as a timber preservative. Before either point can be determined, however, it is essential that the toxic or repellent principle existing in the extracts from the durable timber be ascertained with certainty. This in its turn involves the careful examination of all extracts, and the determination by experiment in the laboratory, and where possible in the field, of the resistant properties of each fraction towards both fungi and termites. Having thus determined the constituent or constituents responsible for the durability of the species under examination, it may be possible to make practical use of the knowledge obtained in either of the above ways or by the utilization of sawmill waste for the commercial production of the toxic materials for subsequent use as a preservative.

In Australia, the question of timber preservation is of great importance for depredations of termites and fungi are common throughout the Commonwealth and are in some cases particularly severe. Amongst the most durable of Australian timbers, the cypress pines (*Callitris* spp.) are outstanding, although the total quantities available for milling are not large. Accordingly, the following three members of this genus, namely, *C. glauca*, *C. calcarata* and *C. intratropica* have been investigated. The results are reported below.

2. Historical.

The volatile oils from various members of this genus have been isolated and examined by Baker and Smith (5). Their work has been discussed in an earlier publication (6). Two fractions were specifically examined by them, namely, (i) a crystalline sesquiterpene alcohol proved to be identical with guajol, and (ii) a liquid which they termed " callitrol." It was assumed, but without any experimental evidence, that the " callitrol " which was present in the oil from all the species examined was the material so objectionable to termites. Oshima (7) on the other hand, working with a sample of cypress pine (species not stated) from Queensland, carried out definite experiments showing that the volatile oil obtainable from it successfully preserved samples of Japanese pine from termite attack, while untreated controls were destroyed. Owing to the presence of a large percentage of guajol in the oil, he assumed that this sesquiterpene alcohol was the effective agent in the prevention of attack. As a result, he searched for a cheap source of sesquiterpene alcohols other than guajol which could be used as preservatives. This source was found in the higher-boiling fractions of camphor oil, and these fractions were subsequently successfully used as commercial preservatives. Oshima's work shows abundantly the value of studying the reasons for durability and emphasizes the fact that such investigations are not without practical application. (While camphor oil may be an economic preservative in Japan and its colonies, it is not so in Australia).

The opinions of Baker and Smith on the one hand and Oshima on the other as to the cause of the resistance of cypress pine are conflicting and, in neither instance, were all of the products that can be extracted from the wood examined. Nothing is known of the chemical constitution of the products isolated from the volatile oil. In view of the conflicting evidence, and the dearth of information regarding the products of the alcoholic and aqueous extracts, it was decided to make a further examination of the extractives from the wood of these species.

3. Experimental.

(i) *Isolation and Separation of Extractives.*—The collection of material for these experiments was accomplished through co-operation with the Commonwealth Forestry Bureau and the Forests Departments of New South Wales and Queensland. In this manner the following authentic samples were obtained :—

Callitris glauca—

(*a*) One large slab of truewood* from New South Wales.
(*b*) One bag of sawdust collected in the Pillaga district, New South Wales. This sawdust represented mill waste and was a mixture of sapwood and truewood.
(*c*) A log 4 feet long and 16 inches in diameter from Dalby, Queensland.
(*d*) Two small blocks from west of Forbes, New South Wales.

Callitris calcarata—Two 12-ft. lengths of truewood from the Pillaga district, New South Wales.

Callitris intratropica—One small log from the Northern Territory.

The wood from these species was utilized in the form of coarse sawdust for the aqueous and alcoholic extractions and as thin shavings for the steam distillation. In all experiments, truewood was used as far as possible.

(*a*) *Steam Distillation.*—In this process the volatile oil was obtained in each case from 2 to 3 kg. of shavings. The oil was separated from the distillate by extraction with ether.

(*b*) *Alcoholic Extraction.*—Coarse sawdust, in lots of 50·70 grammes, was extracted in large glass soxhlet extractors with 94 per cent. alcohol for five to six hours, which time was found to be sufficient to remove the greater proportion of the soluble materials. In each case 2 to 3 kg. were extracted in this manner. The extracts were concentrated by removal of the alcohol by distillation and the residue was subjected to steam distillation to separate the volatile oils. Quantitative determinations of the alcohol soluble material were carried out on 80 to 100 mesh sawdust.

The volatile oils, obtained from the steam distillation of both the shavings and the material extracted by alcohol, were subjected to the same treatment, viz., extraction with 10 per cent. sodium hydroxide solution in order to remove phenolic and acidic substances. The portion that did not dissolve in the alkali, on standing, partly solidified, forming a mass of white needles which were then filtered and purified by recrystallization from dilute alcohol (m.p. found to be 90° C.). This product was evidently the sesquiterpene alcohol guajol referred to by previous workers. The alkaline filtrate, remaining after removal of the crystals, was extracted with ether to remove traces of oil. The latter contained some guajol as well as products possessing an agreeable odour reminiscent of that obtained from freshly-cut surfaces of the wood. This oily mixture was distilled under reduced pressure, and separated into several fractions, namely :—

1. b.p. 140° to 150° at 16 mm.
2. b.p. 150° to 160° at 16 mm. containing guajol.
3. b.p. 160° to 170° at 16 mm.

In the toxicity tests to be described later, this oily mixture, prior to fractionation, has been referred to as sweet-smelling oil.

* Truewood refers to that portion of the tree existing between the sapwood and the pith or heart. This term has been adopted because of the common practice in Australia of using the words "heart" or "heartwood" to describe that part of the centre of the tree affected by rot, or of no appreciable strength.

The alkaline extract, after removal of the guajol and the sweet-smelling oil, was acidified and the oil, thus freed, extracted with ether. Distillation of this oil under reduced pressure showed that the greatest proportion distilled between 150° to 156° at 18 mm., while a further fraction distilled between 156° and 172° at 18 mm. It was evident that the fraction boiling between 150° and 156° C. at 18 mm. represented a fairly pure product. The boiling point of this fraction was determined and found to be 245° at 715 mm. and its specific gravity was $0 \cdot 9783^{\frac{15}{15}}$°

It is considered that this fraction is the main constituent of the so-called phenol isolated by Baker and Smith and named by them callitrol. Supplies were forwarded to Dr. V. M. Trikojus of the University of Sydney, who undertook the investigation of the chemical constitution of the product. The results of his investigations will be published in due course, but it is of interest to record here that the so-called phenol has been shown to be an acid.* The name callitrol is, therefore, not appropriate, and it is suggested that callitric acid be substituted for it.

The semi-solid mass remaining after the removal of the volatile oils from the material extracted by alcohol, was mechanically separated from the aqueous liquor and exhaustively extracted with ether. The greater proportion dissolved and this, after removal of the ether, was distilled under reduced pressure. A small quantity of a dark-greenish-blue oil b.p. range 180° to 193° C. at 57 mm. was obtained. The residue was removed from the flask and on cooling set to a hard mass. The fraction insoluble in ether was also sparingly soluble in alcohol and was found to contain some inorganic materials. Although no tests were carried out, it seems likely that the latter correspond to the manganese compounds recorded by Baker and Smith for the members of this genus (8). This non-volatile material extracted by alcohol is undoubtedly resinous in nature. Chemical examination of the constitution of the resinous material was not considered essential for this work, and in later experiments the two fractions, namely, (*a*) material soluble in ether, and (*b*) material insoluble in ether, were used.

The various fractions isolated from the wood of this genus and later used in toxicity experiments were then as follows :—

1. Guajol.
2. An oil, insoluble in alkali, with a sweet odour, containing some guajol, and possibly hydrocarbons and aldehydes.
3. A liquid acid boiling at 150° to 156° at 18 mm.
4. A second fraction of 3 boiling at 156° to 172° C. at 18 mm.
5. A viscous non-volatile oil b.p. range 180° to 193° C. at 57 mm.
6. A resin-like compound soluble in ether.
7. A resin-like compound insoluble in ether but containing some inorganic material.

These products were isolated from each of the three species investigated, but the percentage present differed in each case.

(*c*) *Hot Aqueous Extraction.*—Coarse sawdust (300 grs.) was extracted with 3 litres of distilled water for three hours at the temperature of boiling water. The aqueous extract was filtered from the sawdust and concentrated to approximately 200 c.c. for use in toxicity experiments.

(*d*) *Cold Aqueous Extraction.*—Coarse sawdust (300 gms.) was extracted for 48 hours with 3 litres of distilled water at room temperature. The filtered extract was concentrated to approximately 200 c.c. for use in toxicity experiments.

* In a private communication, Dr. Trikojus has informed the authors that the acid has been proved to be identical with l – citronellic acid.

Yields of Products.—Details of the yields of the products obtained from the three species investigated by the various treatments are shown in Table I. It will be noted that in general the samples of *C. glauca* and *C. calcarata* investigated, contained similar amounts of the various constituents. On the other hand, *C. intratropica*, the species from Northern Territory, contained nearly twice as much alcohol soluble material, and, in addition, possessed considerable amounts of volatile material in which guajol predominated. It seems likely that for these reasons this species was the one used by Oshima in his experiments.

TABLE I.—SHOWING YIELDS OF VARIOUS EXTRACTS.

Species of *Callitris* investigated				Glauca		Calcarata	Intratropica
Source of sample				N.S.W.	Sawdust from Pillaga, N.S.W.	Dalby, Qld.	Pillaga, N.S.W.	Nor. Terr.
Percentage soluble in alcohol (quantitative)				10·6	10·4	..	8·28	19·3
Percentage soluble in hot water				..	7·56	..	5·58	..
Percentage soluble in cold water				..	5·50	..	5·13	..
Percentage volatile oil by steam distillation of shavings	Total			2·88	..	1·53	1·44	4·41
	Guajol	In wood		0·29	..	0·13	0·21	3·87*
		In volatile oil		10·2	..	8·80	14·2	87·0*
	Sweet-smelling oil	In wood		0·55	..	0·37	0·45	..
		In volatile oil		19·1	..	24·40	30·7	..
	Acid constituents	In wood		1·71	..	0·63	0·80	0·61
		In volatile oil		59·4	..	41·9	54·6	15·0
Percentage extracted by alcohol in large scale experiments	Total			6·79	6·72	..	4·84	..
	Percentage volatile in steam	In wood		3·3	1·27	..	1·35	4·03
		In total extractives		48·5	18·8	..	28·0	..
		Guajol	In wood	0·31	..	..	0·13	1·58
			In volatile oil	9·5	..	..	11·0	45·9
		Sweet-smelling oil	In wood	0·56	..	..	0·53	1·69
			In volatile oil	17·1	..	..	40·0	42·1
		Acid constituents	In wood	1·8	..	..	0·61	0·49
			In volatile oil	53·8	..	..	46·0	12·3
	Percentage non-volatile in steam	In wood		3·49	5·45	..	3·49	..
		In total extractives		51·2	81·1	..	72·0	..
		Resin soluble in ether	In wood	2·62	5·0	..	2·42	..
			In total extractives	38·5	74·4	..	50·0	..
		Resin insoluble in ether	In wood	0·87	0·45	..	1·07	..
			In total extractives	12·8	6·6	..	22·1	..

* Mixture of guajol and sweet-smelling oil, in which guajol predominated.

The low yields of volatile oil from the *C. glauca* sawdust collected in the Pillaga District, New South Wales, were expected, as this material was sawmill waste from both sapwood and truewood and had probably lost volatile constituents as the result of exposure before collection.

(ii) *Toxicity Tests Towards Fungi.*—The toxicity of the various products isolated as described above was determined towards the wood-destroying fungus, *Fomes annosus*, by means of laboratory tests. The culture medium used in the experiments was prepared from the following:—

Merck's Agar	.. ..	15 gm.
Saunders' Malt Extract	..	25 gm.
Distilled Water	.. ..	1,000 c.c.

To weighed portions of sterile agar in different flasks known amounts of each product were added. In this way, definite concentrations of each material to be tested were obtained. Where solution in the culture media was not complete, and this was generally the case, thorough mixing was carried out before transferring the media to sterile culture tubes. The latter, each containing approximately 10 c.c., of media were sloped. For each concentration of each material tested, seven tubes were prepared thus, four of these being inoculated by means of mycelial flecks of the fungus, and the remaining three used as controls. At the same time four tubes, containing sterile media alone, were inoculated to show the normal growth of the fungus. In the preliminary experiments the concentrations of each material tested were 0·01 per cent, 0·1 per cent., and 1 per cent. Later, on the basis of results obtained at these concentrations, further experiments at other concentrations were carried out in order to determine the limits at which growth of the fungus was inhibited. The temperature of incubation was kept between 25° to 27° C. In the case of the volatile oils, the tubes were covered with waxed paper in addition to the usual cotton wool plug. Observations and measurements of growth, where necessary, were carried out every twelve hours. Results obtained for the four tubes prepared for each concentration of each material tested were averaged and the average used in plotting growth curves. These curves were compared with those obtained from the average growth of the four controls (normal growth of fungus) and in this manner the percentage retardation, caused by the added material, calculated. In those cases where no growth occurred over a period of four weeks, the original transplant was removed to a tube of pure culture medium, in order to determine whether the fungus had been killed.

At the three concentrations tested, guajol had no great effect on the growth of the fungus. The sweet-smelling oil had a definite retarding action and the retardation at 1 per cent. concentration was shown to be approximately 94 per cent. It was considered unnecessary to determine the actual killing point of this oil. The acid fractions proved to be extremely toxic and the fungus was killed at a concentration of 0·015 per cent. Repetition of the experiments, both under the same conditions and when using stoppered Erlenmeyer flasks for growth studies, gave similar results in each case. The viscous non-volatile oil did not inhibit growth of the fungus at 0·01 per cent. concentration, but did inhibit at the 0·1 per cent. concentration. Further experiments to determine the actual killing point of this fraction were considered unnecessary as such a small quantity of the oil was found in the wood. The resinous materials were not soluble to any extent in the culture media and even when dispersed as well as possible did not cause any retardation of growth. Thus, from these experiments, it appeared that the acid fraction was the probable cause of the resistance of the woods of this genus to wood-destroying fungi.

The hot and cold water extracts prepared as described above were used in toxicity tests in the manner described by Hawley, Fleck and Richards (9). The concentrated sterile extracts from both *C. glauca* and *C. calcarata* were utilized in toxicity tests.

In the preparation of the media, part of the water used was replaced by these hot and cold aqueous extracts in sufficient quantity to give media containing in one case 50 per cent. of the extract and in the other 10 per cent. of the extract.

The results of tests towards the fungus, *Fomes annosus*, expressed in terms of percentage retardation, are shown in Table II.

TABLE II.—SHOWING PERCENTAGE RETARDATION OBTAINED WITH AQUEOUS EXTRACTS FROM C. GLAUCA AND C. CALCARATA.

		Concentration of Aqueous Extract.	Percentage Retardation.
		%	
Aqueous extract from *C. glauca*	Hot	50	100
		10	90
	Cold	50	100
		10	50
Aqueous extract from *C. calcarata*	Hot	50	100
		10	90
	Cold	50	100
		10	90

In the course of this work, a sample of *C. glauca* was received from west of Forbes, New South Wales, showing a definite heart rot. The wood in the rotten area and in close proximity was found to be comparatively free from volatile constituents, while that from sound wood showed normal amounts. A culture of the rot was obtained, and this culture was used in toxicity tests with the volatile acid. Results were not definite, owing to the very slow growth of fungus, but indications were that growth was inhibited at a concentration of 0·015 per cent. of the acid.

(iii) *Resistance Tests towards Termites* (in co-operation with G. F. Hill, Senior Entomologist, Division of Economic Entomology).—Unfortunately, it is impossible to carry out simple toxicity tests with termites. The only available means of testing the resistance of any chemical is by impregnating it into non-durable wood and exposing the treated and some untreated controls to termite attack. If the controls are destroyed and the treated samples unattacked, it seems logical to conclude that the treatment has made the wood distasteful and therefore resistant.

In the series of experiments to be described, the sapwood of *Pinus radiata* was chosen as the non-durable wood for treatment with the various fractions to be tested, experiments having shown that this wood was readily attacked by termites. Alcoholic solutions of each of the isolated fractions listed above and of the original alcoholic extract were prepared, in concentrations corresponding to the percentage of the same material in wood of *C. glauca*. The hot and cold aqueous extracts prepared as described earlier were also used. Each of these solutions was used to treat a number of sticks (6″ x 1″ x ¼″) of *P. radiata*. The latter were oven-dried at 105° C. for one to two hours prior to their immersion in the treating solutions. They were completely immersed for at least 24 hours, after which they were removed and the alcohol allowed to evaporate at room temperature. Control samples were treated with alcohol alone. The weight of the samples before treatment and the total absorption in c.c. were recorded in each case. It was thus possible to calculate approximately the amount of the material being tested actually present in each stick. This method of treatment was admittedly imperfect, but was considered to be satisfactory for the purpose of the experiments.

The treated samples were used in a series of field tests and were placed together with controls, in the mounds of *Eutermes exitiosus* on Black Mountain, Canberra, F.C.T. Samples were exposed in this manner for periods up to twelve months, examinations being made from time to time. Results were negative, for although all samples were incorporated into the mounds by the termites, the controls in most cases showed no signs of attack.

It was considered that further exposure in the mounds was useless, as the termites had plenty of other food material available. For this reason, representative treated samples were transferred, together with controls, to laboratory colonies. These laboratory colonies made up of nest material containing termites were kept in stoppered glass jars, and in each jar three to four treated samples and two controls were placed in position round the inside. In the first series of laboratory tests, samples were left in contact with the termites in glass jars for a period of seventeen days. All except those impregnated with the ether soluble resin and the complete alcoholic extract showed evidence of attack. The experiments were therefore repeated, and in this series the samples were left in contact with the termites for two months. Again the samples treated with the ether soluble resin and the complete alcoholic extract were untouched, while the remainder, including controls, were destroyed.

As all samples in these experiments had been previously exposed to the weather for varying periods during the summer months, it was considered that some loss of volatile constituents had occurred. Therefore, in a final series of tests freshly impregnated samples were used. Sticks of *P. radiata*, 4″ x 1″ x ¼″ in size, were treated as before with alcoholic solutions of the following :—Guajol, 0·3 per cent. ; sweet-smelling oil, 0·3 per cent. ; volatile acid, 1·4 per cent. ; non-volatile viscous oil, 0·23 per cent. ; ether soluble resin, 1·9 per cent. ; ether insoluble resin, saturated solution. Each of these solutions was used to impregnate four sticks, and each group of four sticks treated with the same solution, together with two controls, were placed in separate laboratory colonies of termites (*Eutermes exitiosus*). The progressive attack of the termites on these samples was determined by examination of one pair of samples, one treated and one control, from each colony at the end of 19 days ; a second pair, one treated and one control, at the end of 42 days, and the final pair of treated samples at the end of 192 days. Up to the end of the 42 days, the only samples showing no signs of attack were those treated with the volatile acid and the ether soluble resin. All others as well as all controls, were badly attacked. However, at the end of the 192-day period, samples previously resistant showed signs of attack. It seems probable then, that the termites will, when necessary, feed on undesirable material. During this 192-day period, the colonies were replaced six times in order to maintain an active colony in contact with the samples. Whether the dwindling of these colonies was due to the toxic properties of the materials present in the wood or to natural causes was not definitely determined. However, the fact remains that the wood impregnated with either the ether soluble resin or the volatile acid proved definitely more resistant than that treated with any of the other products isolated from the extractives of the cypress pines investigated.

Discussion of Results.

The present investigation has demonstrated fairly conclusively that the resistant properties of the cypress pines are due to the presence of (i) a volatile acid and (ii) resinous material. The former is in all probability the main constituent of the so-called phenol " callitrol " recorded by Baker and Smith and assumed by them to be responsible for the resistant properties of these

timbers. Oshima, on the other hand, suggested that these properties were due to the presence of guajol, which in the present investigation has not proved either toxic to the fungus *Fomes annosus*, or repellent to termites. The resistance of the samples treated by him with the volatile oil from cypress pine was undoubtedly due to the presence of the volatile acid. This acid, for which the name callitric acid has been proposed, is both toxic to fungi and repellent to termites, but when used alone as a preservative is slowly volatilized or decomposed on exposure to air. In the wood of the cypress pines, it is evidently held *in situ* by the resinous materials present. The latter have also been shown to be distasteful to termites, but did not prove toxic to fungi. Anatomically, the wood of the cypress pines does not show resin ducts and is comparatively free from wound tissue. The extraneous materials responsible for its durability exist in the medullary ray cells and the parenchyma tissue. (See Plate 3, Fig. 1.)

Having thus determined the constituents responsible for the durability of the woods under examination, it is appropriate to consider the possible practical utilization of the knowledge gained along the lines suggested in the introduction. The use of sawmill waste for the extraction of the toxic materials is not, in this instance, economical. Synthesis of the toxic volatile acid, the constitution of which has been studied by Dr. V. M. Trikojus, is possible, but not likely to prove commercially practicable. The most promising line of investigation is the possible utilization of materials, either naturally occurring or synthetic. There are considerable resources of these materials in Australia, and attention focussed on these as a result of this investigation has already disclosed one, at least, which may prove of considerable economic value in this connexion. The Division of Forest Products is at present following up this aspect and some interesting results have been obtained. These, it is hoped, will be published in the near future.

5. References to Literature.

(1) See Hawley and Wise "The Chemistry of Wood," Chemical Catalog. Co. Inc., New York, 1926, pp. 304–308.

(2) Schmitz. School of Forestry, University of Idaho. *Idaho Forester*, p. 6 (1922).

(3) Hawley, Fleck, and Richards. *Jour. Ind. Eng. Chem.* **16**: 699, 1924.

(4) Sowder. *Jour. Ind. Eng. Chem.* **21**: 981, 1929.

(5) Baker and Smith. "A Research on the Pines of Australia," Government Printer, Sydney, 1910, pp. 60–66.

(6) Cummins, Dadswell, and Hill. *Jour. Coun. Sci. & Ind. Res., Aust.* **3**: 138, 1930.

(7) M. Oshima. "Proceedings Pan-Pacific Science Congress" (Australia) 1923, pp. 332–341.

(8) Baker and Smith. Loc. cit., pp. 80–84.

(9) Hawley, Fleck, and Richards. Loc. cit.

The Large Stomach Worm of Sheep: Control by means of Carbon Tetrachloride.

By I. Clunies Ross, D.V.Sc.

The work described in the article that follows forms part of the programme that is being undertaken by the Division of Animal Health under the Australian Pastoral Research Trust-Empire Marketing Board scheme (see this *Journal*, August, 1931, p. 134). The parasitological investigations on the programme are being undertaken by Dr. Clunies Ross and his colleagues, with headquarters at the F. D. McMaster Animal Health Laboratory. The particular investigations on the large stomach worm of the sheep were located at the "Meteor Downs" Station of Mr. Darcy Donkin who, in this and other ways, has very considerably helped the various researches which are being carried out under the direction of the Council.—Ed.

1. Introduction.

On the "Meteor Downs" field station of the Division of Animal Health, experiments have been conducted recently to determine the efficiency of carbon tetrachloride and other medicinal agents in controlling the large stomach worm of sheep, *Haemonchus contortus*, and the nodule worm, *Oesophagostomum columbianum*.

Four groups, each containing 50 sheep, were employed, each group consisting of six to seven months old lambs, which had been kept under natural conditions until the beginning of the trial. Each group was run in an 80-acre paddock which, under normal conditions, would have provided ample feed. All received a basal lick of ground rock phosphate and salt.

The treatment adopted in the several groups was as follows:—

Group 1.—Received monthly treatments with carbon tetrachloride, of which 2 c.c. were administered in 3 c.c. of liquid paraffin, and to the basal lick was added sodium arsenite one part and copper sulphate four parts per 1,000.

Group 2.—Received the same additions to the basal lick as group 1, but no other treatment. The administration of these medicinal agents in the form of a lick has been found in South Africa to be of some effect in controlling not only *H. contortus*, but also *O. columbianum*.

Group 3.—Received tetrachlorethylene in the form of 1 in 4,000 parts suspension* in the drinking water. This medicament was administered daily in the drinking water throughout the trial.

Group 4.—Control Group.—Received no medicinal treatment, but the same phosphatic lick as groups 1, 2, and 3.

Determination of Results Obtained.—It is hoped to be able to determine the effects of the several treatments given, not only by the decrease in degree and type of worm infestation, but also by considering the increase in weight of the several groups, and also the variations in wool production which might occur. The sheep were weighed at the beginning of the trial, and subsequently at monthly intervals. In addition, faecal samples were forwarded from 10 per cent. of each group at the time of the monthly weighing, and these were cultured at the McMaster Laboratory. Subsequently, the type and degree of infestation in the various groups were determined by the examination of the larvae from these cultures.

* The suspension of tetrachlorethylene was made by Mr. H. Finnemore, Department of Pharmacy, University of Sydney. Details of the preparation of aqueous suspensions of tetrachlorethylene and carbon tetrachloride will be given in a later paper, dealing with the results of experimental trials carried out at the McMaster Animal Health Laboratory, Sydney.

Weather Conditions during the Trial.—At the time the trial was due to commence, conditions were very dry, and it was feared that the tests would have to be abandoned owing to the shortage of feed in the several plots. During March, however, 90 points of rain fell, and it was decided to proceed with the experiment at the beginning of April. Unfortunately, during June very dry weather conditions returned, and soon it became evident that the weights of the sheep could not be taken as an index of any effect, beneficial or otherwise, of the treatments given. During the five months from March to July, only 255 points of rain fell, and conditions became progressively worse until at the end of July it was found necessary either to hand-feed or to abandon the trial. Owing to the extremely unfavorable prospects throughout the district, it was decided to abandon the trial and to determine the effects so far of the treatments solely by the degree of infestation found in the several groups. It will thus be seen that the trial only proceeded for a little less than four months, 1st April to 21st July.

2. Type of Infestation during the Trial.

Several sheep, from the same group as that from which the experimental sheep were taken, were killed at the beginning of the trial and were found to have moderate degrees of infestation (some hundreds) with the large stomach worm, *H. contortus*, light degrees of infestation with the small stomach worm, *Trichostrongylus* spp. and very light or no infestation with *O. columbianum* (nodule worm). Though the nodule worm occurs commonly in this district, it is thought that the dry weather which preceded the commencement of the trial had not been favourable to building up any considerable infestation with this parasite.

Of the first lot of faeces cultured at the time the trial actually started, all groups showed from 80 to 100 per cent. infestation with *H. contortus*, a low percentage of infestation with *Trichostrongylus* spp., and a negligible degree of infestation with *O. columbianum*.

One month later, the degree of infestation in group 1 (carbon tetra, chloride and medicinal lick) was appreciably lighter than in groups 2, 3, and 4, only individual larvae being recovered from all but one sheep in group 1- although all groups showed quite light infestations.

After two months, group 1 again showed only individual larvae present in the faeces, whereas in the other lots *H. contortus* still formed from 60 to 90 per cent. of the larvae recovered.

After three months, group 1 was negative for *H. contortus* in three out of the five animals from which faeces were examined, whereas the other lots still showed from 74 to 98 per cent. of this parasite. In no group was there any appreciable variation in the degree of infestation by *Trichostrongylus* spp. or *O. columbianum*.

After the fourth monthly drenching of group 1, it was decided that owing to drought conditions the trial should be abandoned, and three weeks later five sheep were killed in each lot, and their stomachs examined. Unfortunately, the stomach of one sheep in group 1 was accidentally lost, so that only four sheep were examined from this lot. Of these, two were completely negative for *H. contortus*, and two showed a single male worm each. The four animals were, therefore, for practical purposes, completely negative.

Group 2 (sodium arsenite and copper sulphate lick) gave an average number of *H. contortus* of 121 per sheep.

Group 3 (tetrachlorethylene in drinking water) gave an average of 116 per sheep.

Group 4 (control) gave an average of 253 *H. contortus* per sheep.

All groups showed light infestation with *Trichostrongylus* spp.

3. Discussion.

It is thought that, though the trial was rendered largely abortive owing to the unfavorable weather conditions, some definite indications could nevertheless be drawn.

Firstly, it is apparent that four treatments at monthly intervals with carbon tetrachloride in dose rate of 2 c.c. had almost completely eliminated *H. contortus*. Though this conclusion is based on the faecal examination of only 10 per cent. of sheep each month, and on the post-mortem examination of less than 10 per cent. in the case of group 1, it is thought that, when taken in conjunction with the progressive decrease in the degree of infestation found throughout the trial, the conclusion is reasonable. It is possible that the administration of medicinal lick to this group contributed to the favorable result, but from comparison with group 2, it is not thought that the lick contributed very materially to the result. Although fewer worms were found in group 2 and group 3, when compared with the control untreated group 4, it is not thought that the results are sufficiently conclusive owing to the fact that individual variation in the sheep may have accounted for this difference.

It may be stated here that consumption of the medicated lick in group 2 for the four months of the trial was as follows :—First month 18 lb., second month 19 lb., third month 21 lb., thus giving an average daily consumption of from 5·5, 5·8, and 6·4 grms. per sheep. Group 1 consumed 12 lb., 18 lb., and 24 lb. for the same months, or 3·7 grms., 5·5 grms., and 7·4 grms. per day per sheep.

In group 3, the consumption of the medicament in the drinking water varied from 45 to 125 gallons per week, the consumption of drinking water in this group being less than in the other trial groups in June, but equalling them in July. A consumption of 125 gallons would equal 2½ gallons per sheep per week, or under half a gallon per sheep per day.

It must be remembered, in evaluating the results given by carbon tetrachloride and the medicated lick, that climatic conditions probably favoured the effects of the former since, owing to the excessively dry conditions, the animals were not likely to be pre-disposed to any marked risk of fresh infestation.

It is worthy of note that, given dry conditions, a determined attack on *H. contortus* will have more likelihood of being completely effective than it would under more normal conditions of rainfall. Therefore, it is considered that where an attempt is to be made to eradicate this parasite, advantage should be taken of dry conditions, whether in winter or summer, to effect this end, since under such conditions practically no fresh infestation is likely to be acquired by the sheep, while the mortality of the larvae on the pastures is very high.

4. Conclusion.

Under dry conditions, it was found that four treatments with carbon tetrachloride at monthly intervals were almost completely effective in eliminating *Haemonchus contortus* from a flock of 50 sheep, as determined by repeated faecal examination, and post-mortem findings in a small proportion

of them. While the simultaneous consumption of sodium arsenite and copper sulphate in the lick may have contributed to the results, it is not considered that these drugs were of material importance.

Although sheep receiving medicated lick containing sodium arsenite and copper sulphate had a lower average infestation than control untreated sheep, nevertheless the results obtained were not considered conclusive.

The sheep receiving tetrachlorethylene in the drinking water had also fewer worms than the controls. Results again were not conclusive.

Given prolonged dry conditions, it is concluded that regular monthly treatment with carbon tetrachloride in 2 c.c. doses may be expected to effect eradication of *Haemonchus contortus* in five or six months.

The Poisoning of Stock on the Georgina River.

The Native Fuchsia and Gidgea.

By H. Finnemore, B.Sc. (Lond.), F.I.C.

H. Finnemore, Department of Pharmacy, University of Sydney, is the Chairman of the Poison Plants Committee formed by the Council some time ago (see this *Journal*, **1** : 56, 1927, and **2** : 40, 1929). The Committee controls work in which various branches of the New South Wales Department of Agriculture, the University of Sydney, and the Council were co-operating. Unfortunately, owing to the recent restriction of its finances, the Council is no longer able to support the Committee financially as it did in the past. The various members, however, have very kindly continued to act in their former honorary capacity, but without the services of investigators the Council was previously able to afford them.—Ed.

1. Introduction.

The question of the poisoning of stock on the Georgina River, North Queensland, was brought to the notice of the Poison Plants Committee of the Council at the end of 1927 by a letter from the Council's Chief Executive Officer (Dr. Rivett), enclosing a communication from the Chairman of the Development and Migration Commission (Mr. H. W. Gepp), who, on a visit to the district, had been impressed by the serious loss of stock, attributed locally to the animals eating "gidgea scrub," *Acacia georgina*. It was therein stated that no real positive results had been obtained, and although feeding experiments had failed to prove that gidgea was poisonous, local residents held that opinion strongly. At the same time it was mentioned that "fuchsia" was suspected. We shall see in the following account that there existed at that time abundant evidence against fuchsia, and the real difficulty appears to have been, as it still is, to bring home to local opinion the findings of scientific experiments. Information kindly placed at the disposal of the Committee by the Under-Secretary of the Department of Agriculture, Brisbane, showed that the trouble was known in 1896, as a reference to it appears in Botanical Bulletin XIII. of the Department.

2. The Losses Involved.

The Committee has no complete information as to the total loss of stock involved, but from reports at its disposal, the following quotations have been abstracted, and they show that the loss is considerable.

> "On the strip of country 150 miles long, extending from Lake Nash down the Georgina to Roxborough, cattle die in hundreds every year from August to November."

In another report it was stated that at Tobermorey Downs, over 50 head of full-grown fat cattle had died during the month of September, 1918.

> ". . . . Many thousands pounds' worth of cattle and sheep are lost on this belt of country each year."

3. Symptoms of Poisoning.

Local opinion seems to be puzzled by what is called the absence of symptoms; all reports state that animals die suddenly without a struggle. One observer notes that the extra exertion of climbing out of the drinking place, the excitement involved in fighting or playing, the noise of the discharge of a gun, were all sufficient to bring on a fatal result. It is significant that this sudden onset of symptoms at once suggests to the veterinary observers the possibility of prussic acid poisoning.

4. The Plants Suspected.

(*a*) *Eremophila maculata*, the native fuchsia.—Of the plants mentioned in Dr. Rivett's letter referred to above, there is abundant evidence that the native fuchsia is implicated. In 1910, Mr. O'Boyle, M.R.C.V.S., gathered leaves of the native fuchsia from well-cropped bushes, and as the result of feeding tests, confirmed its toxicity. Conclusive evidence of the nature of its poisonous constituent was then obtained by analysis, Messrs. Brunnich and Smith* showing that the plant contained a cyanogenetic glucoside in somewhat large amount.

Confirmatory evidence of the above experiments was subsequently obtained by the officers of the Queensland Department of Agriculture. Only two fatal results need be mentioned. In one, the young growth of fuchsia produced symptoms of poisoning five minutes after its administration, death resulting an hour later. In another test 4½ lb. gave a fatal result in 40 minutes.

(*b*) *Gidgea Pods.*—In the report of Mr. O'Boyle, who investigated this matter in 1910, it was stated that gidgea pods were supposed locally to be the cause of the fatalities, but in that year, although deaths occurred, there were no pods. Further, Mr. O'Boyle came to the conclusion that the leaves of gidgea exerted only an astringent action.

The evidence against gidgea pods falls into two classes; firstly there are the observations of the local stock-men, whose opinions may not be lightly disregarded and of which the following quotations are typical. "Consensus of opinion in these parts has it that gidgea is the poison, but there is no proof." Again "I am convinced that gidgea is the poison." Perhaps the most striking piece of circumstantial evidence against gidgea is contained in a letter from Mr. G. R. Beauchamp, of Westward Ho, and published in the Annual Report of the Department of Agriculture and Stock, Brisbane,

* *Q. Agric. Jour.*, **25**: 291. 1910.

1917–1918, p. 68, as follows :—" I had a good chance here the other day of proving beyond doubt that the gidgea while in pod will poison cattle. Being short of grass near the homestead, I broke down some gidgea limbs for the goats. Just then the milking cows were let out of the yard and two of them went and ate some of the gidgea I had broken down for the goats. These two cows got poisoned. When I found this out, I went and had a look at the gidgea and noticed the limbs were heavily laden with pods. It is this bean that, in my opinion, causes all the trouble."

The second class of evidence results from the scientific examination of gidgea pods. Mr. Brunnich examined the seeds of this plant and reported the " presence of considerable amounts of the glucoside ' saponin,' which is a poisonous substance and may cause the death of animals feeding on them." It should be noted, however, that since the date of Mr. Brunnich's experiments, it has come to be recognized that a wide class of substances is included under the term " saponin " ; some of these may be poisonous, whilst others are not, so that even Mr. Brunnich's guarded opinion would require experimental support before the presence of a " saponin " could be taken as evidence of toxicity. Indeed it has been shown that, in one feeding test with 4½ lb. of pods, a yarded beast showed no symptoms of poisoning.

In favour of the harmlessness of gidgea, many quotations might be given, e.g., " Even travelling stock, which eat the pod ravenously are not affected." Again, " While camels live on the pods they are never affected."

5. Other Plants.

The possibility of other plants being concerned in these fatalities is not precluded by the observations hitherto made. In fact, *Atalaya hemiglauca*, known also as whitewood or cattlebush, is recorded to have been found among the contents of the first stomach of an animal poisoned in 1922. Further, among the suspected plants collected in the district in 1910 appears *Sarcostemma australe*, the caustic vine, which has only quite recently been shown by Gilruth and others* to produce fatal results. But the symptoms of poisoning by these two plants differ entirely from those observed on the Georgina.

6. Isolation of the Poison.

The experimental work of the Poison Plants Committee has confirmed the results obtained by Brunnich and Smith, and has shown that the native fuchsia, obtained from Boulia Downs in June, 1929, was strongly cyanogenetic.† In fact this sample yielded a larger proportion (0.824 per cent.) of hydrocyanic (prussic) acid than any other leaf yet recorded, being almost three times as strong as the sample examined by the workers just mentioned, or as the rosewood (*Heterodendron olæifolium*) which hitherto has been the strongest prussic acid yielding plant examined in Australia. The acid occurs bound up in the form of a glucoside, which was isolated from the leaves by the following extremely simple process. The crushed and dried leaves were extracted with ether in a soxhlet apparatus, when in the course of half an hour the glucoside began to separate from the liquid in a crystalline form. The glucoside has been previously found in the bark and leaves of the American medicinal plant, *Prunus serotina*, and is known as prunasin. The ease with which it can be separated from the native fuchsia, taken in conjunction with the extremely high proportion present, viz., from 8 to 10 per cent., makes this plant the most suitable source for the preparation of the glucoside, should a demand arise for it.

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* This *Journal*, **4**: 58. 1931. See also pages 225–231.
† *Jour. and Proc. Roy. Soc., N.S.W.*, **63**: 172–182. 1929.

7. The Enzyme.

It is now well known that for the production of hydrocyanic acid from a plant, two different types of substances must be present in adequate amount, viz. :—

(*a*) The cyanogenetic glucoside.

(*b*) An enzyme capable of splitting this glucoside.

A study of this particular sample of fuchsia showed that the enzyme necessary for the liberation of the prussic acid was present in small amount, so that when moistened with water, only a trace of prussic acid developed. There is, however, no uniformity in this respect, some samples containing, on the other hand, enough enzyme to liberate a somewhat larger proportion of the acid which is present. The fruits also exhibit the same variation, some containing none and others a small quantity of enzyme. In no cases have we found the enzyme in sufficient quantity to liberate the maximum amount of acid that is present, and it is only after the addition of enzyme from other sources that this has been brought about. A consideration of the properties of enzymes and of their presence in the leaves has a direct bearing upon the results of some of the feeding tests. For example, it was found in one case that the administration of $2\frac{3}{4}$ lb. produced a fatal result, but that the use of the liquid obtained from $3\frac{1}{2}$ lb. of boiled leaves produced no ill-effects. The latter result can now be understood when we remember that boiling the leaves with water would detoxicate the plant by rendering any enzyme, which might have been present, incapable of liberating the poison. That one of the causes of the apparent safety of the native fuchsia is due to the deficiency of enzyme is fully borne out by experiment. Feeding tests carried out for the Committee by Seddon and King* have shown that when additional enzyme is administered at the same time as fuchsia leaves or the glucoside isolated from them, death occurs, provided there is sufficient of the leaf or glucoside to provide the requisite amount of prussic acid. They also showed that the potentially fatal dose of such a plant is about 1 oz. for an average sheep.

8. Co-relation of Fuchsia and Gidgea.

It still remains to ascertain if there is any experimental evidence of the observation made locally that gidgea plays a part in these poisoning cases. Experiments showed firstly that prunasin is remarkable in the ease with which it is decomposed by enzymes, and secondly that the distribution of enzymes capable of doing so is fairly wide. In the course of searching for the latter enzymes, it was found that the pods of *Acacia suaveolens*, found locally near Sydney, were especially active whilst in an immature condition, but that they completely lost this property as they developed, for after three weeks further growth, they were inactive. It was also noted that the aqueous extract of these pods concurrently possessed and lost the foaming property usually associated with the presence of a "saponin." This observation at once suggested the examination of gidgea pods from this aspect and although it was only possible to obtain old herbarium specimens collected in 1910, even these still contained some substance which has the property of enzymes in so far as it is capable of bringing about the liberation of hydrocyanic acid from prunasin. Although the Committee has made every effort to obtain fresh pods from the Georgina district, it has so far been unsuccessful. When they can be obtained, a simple experiment will show whether the theory that is suggested is correct, viz., that the immediate

* This *Journal*, **3**: 14. 1930.

onset of poisoning recorded by Mr. Beauchamp was due to the fact that the two cows had a sufficient amount of a cyanogenetic glucoside in their stomachs and that gidgea pods supplied the enzyme necessary for the liberation of a fatal dose of hydrocyanic acid. None of the other common acacia fruits behaves in this way.

9. Onset of Poisoning at the Drinking Places.

There is abundant evidence that there is some relation between the cattle drinking and the onset of poisoning symptoms. It is well known that even when sufficient enzyme is present, its activity may be influenced by the presence of acid or alkali normally present in the body fluids. Experiments carried out with prunasin show that the influence of dilution of the acid, such as would take place when an animal drinks, is to allow the enzyme to exert its decomposing power which had been in abeyance on account of the presence of acid. These experiments will be extended as soon as a supply of fresh gidgea pods are available.

10. Conclusion.

This work was carried out for the Council by the Poison Plants Committee, which endorses the conclusions set out above, that the actual poisonous principle is contained in the native fuchsia, that it is possibly liberated by enzyme from other plants, and as gidgea has been shown to contain some enzyme and to have been eaten by the animals poisoned there seems every reason to believe that gidgea plays a definite but subordinate part in the causation of the mortality.

Addendum.

Since the above was written, Mr. H. H. Cox, Station Manager, Walgra, has kindly supplied specimens of dry fresh gidgea pods and also gidgea leaves. Both pods and leaves have in most cases contained enzyme capable of liberating prussic acid when incubated at about 40° with prunasin. The action appears to vary, for in two cases only was there no liberation, and whilst some specimens gave a somewhat feeble result, others gave a very strong reaction. In some, the pods were the most active, and in other cases the leaves were as active as the pods.

One sample of pods was evidently obtained from the stinking gidgea, *Acacia Gambagei*, for, on incubation, volatile sulphur compounds were liberated which were detected by means of a lead acetate paper. This also liberated the prussic acid.

Specimens of other leaves were also sent and the following have been definitely identified by Mr. E. Cheel, Curator of the National Herbarium. *Atalaya hemiglauca*—As stated above, this has been found in the stomach of poisoned animals. It was found to contain rather more active enzyme than gidgea, but whether this observation has any significance with regard to the suspicion under which the plant has fallen, is unknown. *Leptomeria* spp. and *Santalum lanceolatum* also contained enzyme in significant quantity.

These experiments have been made by Miss J. Brown, B.Sc., and Mr. C. H. Williams, to whom acknowledgment is made.

Sarcostemma Australe (Caustic Vine): A Plant that is Poisonous to Stock.

By J. A. Gilruth, D.V.Sc., and D. Murnane, B.V.Sc.

Summary

Sarcostemma australe, the caustic vine of Australia, has been proved poisonous to sheep, cattle, and horses, as well as certain small laboratory animals.

Two ounces of the plant is sufficient to produce death with certainty in an adult sheep of average size; 32 ounces is fatally toxic to a bovine and a horse.

The symptoms and post-mortem findings are described.

Extracts of the plant have been tested for toxicity.

The toxic action of this plant is almost identical with that of other members of the milkweed family (Asclepiadiaceae) in U.S.A. and South Africa.

1. Introduction.

As indicated in a preliminary note which appeared in a previous issue of this Journal (Vol. 4, No. 1, pp. 58–60), recent feeding tests carried out at the Veterinary Research Institute, Melbourne, have demonstrated conclusively that *Sarcostemma australe*, commonly known in Queensland as "caustic vine," is poisonous to stock. Since that time, a number of further tests have been made. These are reported below.

The plant belongs to the natural order *Asclepiadaceae* (the "Milkweed" family), the members of which are perennial herbs, vines, or shrubs, with milky juice. Some species of the order are used medicinally, chiefly as tonics, emetics, diuretics, and vermifuges. Of the 1,800 known species, a number of milkweeds have been definitely proved to be toxic. Opinions concerning the poisonous properties of *S. australe*, however, are somewhat at variance. In U.S.A., Marsh and Clawson (1) have proved the toxicity of several species of the genus *Asclepias*, including *A. galioides* (the whorled milkweed), *A. mexicana* (the Mexican whorled milkweed), *A. pumila*, *A. verticellata*, var. *geyeri.*, and *A. eriocarpa* (the woolly pod milkweed). Tunnicliff and Cory (2) recently described the toxic action of *A. latifolia*, the broad-leafed milkweed. Certain members of the genus *Cynanchum* are also known to be poisonous. In South Africa, Curson (3) recorded the toxic properties of *C. africanum*, and also referred to the work of Henning who, as early as 1893, proved *C. capense* to be toxic. Concerning our Australian Asclepiads, Ewart (4) states, in regard to the genus *Sarcostemma*, "the shoots of several exotic species are edible, and it is possible that the poisonous properties of our native species have in many cases been exaggerated." Pammel (5) says "the caustic bush . . . . . *Sarcostemma australe* of Australia is regarded in that country as poisonous." Tate (6) in 1881 was informed by a Mr. J. Dixon that he had not known stock to touch the plant until the summer of 1880–1, when cattle on the eastern plains of South Australia lived upon it without water for some months of continued drought. Bailey and Gordon (7) state that W. M. Huchinson, Inspector of Sheep, reported the death of a great number of fat cattle in the Warrego district,

Queensland, as a result of eating this plant, and that the death of sheep following eating of it is also well authenticated. White (8), Government Botanist in Queensland, states that *S. australe* has been suspected of poisoning stock, but that there is considerable doubt on this point.

As there was no record in the available literature of any experimental work having been done previously, it was decided to carry out several feeding tests on sheep, horses, and cattle with the material. A supply was accordingly obtained from "Elderslie" Station, near Winton, Queensland, through the courtesy of the Australian Estates and Mortgage Co. Ltd.* Varying quantities were administered, and it was found that a 2-oz. dose was sufficient to produce death with certainty in an adult sheep of average size.

2. Description of the Plant.

Sarcostemma australe is a leafless, fleshy, climbing, cane-like plant, with a bitter milky juice. It has a characteristic habit of climbing into trees and shrubs from which it hangs down. The numerous stems, which arise from a woody base, are round and jointed, and may grow to a length of several feet. The surface is covered with a greyish white powder, which easily rubs off. The small white flowers are borne in clusters at the joints and are succeeded by pods, 1 or 2 inches long, full of seed, with a tuft of silky white hairs at one end. The plant, a photograph of which is given in Plate 3, is met with in all the Australian States except perhaps Victoria and Tasmania.

3. Experiments with Sheep.

(*a*) *Sheep* 1. Three hundred grams (10 ounces) of the plant was cut into small pieces and covered in a closed vessel with 1 litre of water. It was allowed to steep for two and a half days, the week-end having intervened. A slight degree of fermentation was then occurring. The subject was given by mouth about 500 c.c. of the supernatant fluid at 11 a.m. No symptoms were observed up to 5 p.m., but at 7.30 a.m. on the next day it was found to be very ill. Examined at 10 a.m. on that day, it was found to be lying on the right side, with the abdomen distended and the neck strongly flexed backwards; at the same time it exhibited vigorous and fast co-ordinated running movements with the four legs. This was accompanied by stertorous breathing. The jaws were clenched and held a few wisps of hay between them, but they could be forced open, whereupon efforts were made to close them again. The muzzle and nostrils were covered with frothy saliva.

The pupils were sensitive to light in a normal manner, and the body showed normal reaction to cutaneous stimuli such as pricks. The conjunctiva was markedly congested. Soft but otherwise apparently normal faeces had been passed. The heart was tumultuous, with a rapid pulse. The temperature was 105.6° F., but two hours later it had risen to 106.2° F.

There were periods of comparative relaxation, during which the neck was not stretched backwards, and there were no (or only faint) running movements. Then the vigorous movements would commence again. Later, the running movements were interspersed with periods during which there were clonic spasms of the extensor muscles and arching of the neck. At 3.30 p.m. the temperature was 105.5° F. There was less tendency to the running movements, but instead the limbs were stiffly extended. A peculiar strong wagging movement of the upper ear was noticeable, and during the oscillations of the head the animal continually licked the ground.

* The Council also desires to express its thanks to Mr. J. Edwards, of "Elderslie" Station, for a supply of this plant, the chemical investigation of which is being conducted for the Poison Plants Committee by Professor Earl, Department of Organic Chemistry, Sydney University.—Ed.

It was killed at 4.30 p.m. by bleeding. *Post-mortem* showed nothing abnormal in the abdominal cavity except gaseous distension of the abomasum and small intestine. There was a very noticeable absence of peristaltic movements. No congestion or haemorrhages were found. The lungs, except for a little hypostatic congestion, were normal. About 100 c.c. of clear pleural exudate were present. There were a few haemorrhages on the epicardium of the auricles, particularly the left, and the pericardial sac was distended with about 50 c.c. of clear fluid. The mucous membrane of the turbinate bones was cyanotic. The brain showed no recognizable abnormalities.

(*b*) *Sheep* 2–5. On 29th January, 1931, these animals received the following doses :—Sheep 2—4 ounces of fresh minced vine in bolus form ; Sheep 3—the fluid squeezed by hand from 4 ounces of the fresh minced vine after macerating for fifteen minutes in 10 ounces of water ; Sheep 4—4 ounces of a vine, which had been pulled up some months earlier and allowed to dry, the material being given in bolus form ; and Sheep 5—the fluid squeezed by hand from 4 ounces of this dried vine, minced and macerated for fifteen minutes in 10 ounces of water.

In six hours after administration, sheep 3 showed signs of being affected. The animal seemed restless, was somewhat distressed, and the respirations were hurried. Later it went down and showed definite paddling movements of the limbs, and at the same time marked opisthotonos. The temperature was 108, pulse 200, respirations 180, laboured, and accompanied by grunting during expiration. Marked tympany of the rumen was noted, and vomiting took place. The rumen was punctured with a trocar to relieve this condition. There was a temporary improvement, but the animal was unable to rise. Two hours later its condition was worse. Vomiting was continued, and the animal frothed at the mouth. The " paddling " movements became weaker but continuous. Death took place nine hours after receiving the material.

Sheep 2, 4, and 5 became ill about nine and a half hours after dosing, and exhibited similar symptoms. All three died from twelve to thirteen hours after receiving the material.

On *post-mortem* examination, the visible membranes were very injected, and there was a frothy discharge from the mouth. There was marked tympany of the rumen, all stomachs and intestines. There was little or no congestion of the mucous membrane throughout the digestive tract. A slight excess of peritoneal, pleural and pericardial fluid was present. Petechial spotting of the pericardial sac was noted. In each case there was marked congestion—in some cases amounting to haemorrhage—of the lungs. The other organs appeared normal.

(*c*) *Sheep* 6. Five ounces of the dry vine was minced and macerated in 700 c.c. tap water at 20° C. for 24 hours. The fluid was passed through filter paper. The animal was drenched with 70 c.c. of the infusion. No ill effects followed.

(*d*) *Sheep* 7. Received ½ ounce of the fresh minced vine in bolus form. No ill effects followed. Four days later, the same sheep received 2 ounces of the fresh minced vine in bolus form. Seventeen hours later, the animal was down, unable to rise, and exhibiting characteristic strong paddling movements. There was violent grinding of the teeth, and profuse salivation with frothing at the mouth. The pupils were dilated ; reflexes were retained. There was slight tympany. Urine and faeces were voided freely. Respiration 80, temperature 104·5, pulse 120 ; opisthotonus was, as usual, very marked. Death took place 23½ hours after the administration of the plant material.

Post-mortem examination was made immediately, but nothing striking was observed. There was slight excess of peritoneal pleural and pericardial fluid. There was no inflammation of the mucous membranes of stomach or intestine. A slight degree of tympany was present. The liver was cirrhotic with adult flukes. Otherwise all organs appeared normal.

(*e*) *Sheep* 8. Received 1 ounce of the fresh minced vine in bolus form. The following morning, eighteen hours later, the animal was down and obviously ill. When forced to rise, she staggered about in a "drunken" condition. The gait was very uncertain, and the animal fell when caused to move quickly. The pupils were dilated and vision impaired. Respirations and pulse were normal. Temperature 103.5. Slight tympany was noted. Violent muscular trembling occurred. Faeces and urine were voided frequently. At noon the animal showed considerable improvement, and by the following day complete recovery took place.

(*f*) *Sheep* 8. The object of the following test was to ascertain whether an animal recovered from a previous small dose is rendered resistant to a known fatal dose. Eight days after receiving the above 1-oz. dose, Sheep 8 was given 2 ounces of fresh minced vine in bolus form. The following morning, eighteen hours later, it was very ill, down, and unable to rise. Marked tympany, opisthotonos, and paddling movements of limbs were noted. Respirations were frequent and laboured. Death took place at approximately 23 hours after administration of the plant. *Post-mortem* examination revealed a considerable degree of tympany of stomach and intestines. There was also a rather marked congestion of the whole length of the intestine, which was unusual. The anus and vulva were livid in colour. Otherwise the organs were normal.

(*g*) *Sheep* 9. Received all the fluid that could be expressed by hand from a 20-hour infusion of 2 ounces of the vine, cut in small pieces, in 10 ounces of tap water. No ill effects followed.

(*h*) *Sheep* 10. Received all the fluid that could be expressed by hand from a 20-hour infusion of 4 ounces of minced vine in 10 ounces of water. Ten hours after the animal was observed to be lying on its side, exhibiting paddling movements and shaking the head from side to side. Two hours afterwards, a mild degree of opisthotonos was exhibited, punctuated at intervals of approximately fifteen seconds with arching of the body and violent distension of the limbs. Breathing was laboured, and there was a slight degree of tympanites. Salivation was profuse, accompanied by frequent swallowing. The subject appeared to possess a normal degree of cutaneous sensitivity, reacting to the visits of flies by twitching of the ears and closing of the eyes. An hour and a half later the opisthotonos and the paddling movements became intensified greatly. The rhythmical flexing movements were now limited to the head, the neck being held outstretched. This flexing was accompanied by stiffening of the limbs. There was severe grinding of the teeth and stertorous breathing, while the tail was violently wagged after each attack. Ultimately, struggling gradually ceased, and death occurred 20½ hours after administration of the infusion. No *post-mortem* examination was made.

4. Summary of Symptoms and Post-mortem Appearances in Sheep.

Symptoms of Poisoning.—The animal at first appears restless and somewhat distressed, later develops staggers, and eventually goes down and is unable to rise. The temperature is usually elevated and pulse and respirations are increased, expiration becomes short and rather forced, amounting to a subdued grunt or short groan. The animal appears to be in considerable pain. Then

follows a period of violent spasms, characterized by strong running or paddling movements of the limbs and pronounced opisthotonos. Marked tympany of the rumen is observed and vomiting may occur. There is usually champing of the jaws, grinding of the teeth, and profuse salivation. Clonic spasms may appear interspersed with periods of relaxation. The pupils are dilated, reflexes are retained, and urine and faeces are voided freely. Gradually the spasms become less violent, the running movements weaker, and death follows. In the main the symptoms are very similar to those recorded by Marsh and Clawson in U.S.A. and by Curson in South Africa with plants of the same family (see page 225).

Post-mortem examination in most cases reveals no very striking abnormality. The visible mucous membranes are usually highly congested. In the abdominal cavity there is considerable gaseous distension of the rumen, abomasum and small intestine. There is a marked absence of peristaltic movement. In the thoracic cavity there is excess pleural and pericardial fluid. The pericardium and epicardium occasionally show ecchymoses. (The mucous membrane throughout the entire length of the digestive tract appeared normal in all cases except one.) The lungs in several instances showed congestion, and even haemorrhages. The brain shows no visible abnormality. All other organs are apparently normal.

5. Experiments with Cattle and Horses.

Cattle.—A yearling bull received 8 ounces of minced vine in bolus form without ill effects.

Five days later the same animal received 32 ounces of minced vine in bolus form. Fourteen hours afterwards he was observed to be down, extremely tympanitic, paddling vigorously, frothing at the mouth, and bellowing. Half an hour later death took place. *Post mortem* examination revealed the rumen and abomasum to be enormously distended with gas. Apart from that, the only abnormality was a marked congestion of the liver with haemorrhages beneath the capsule.

Horses.—An aged, light draught horse received 20 ounces of minced vine in bolus form without apparent ill effects.

Five days later, he received 32 ounces of minced vine in bolus form. Twenty hours afterwards, the animal was noted to be very ill, and an hour later was down and unable to rise. He showed stertorous breathing, dilated pupils, occasional paddling movements, general trembling, profuse salivation —to such an extent that there was a large pool of saliva beneath the head. The temperature was 98, pulse 88, respiration 28. There was no passage of faeces, but a partial prolapse of the rectum. Frequent fits of violence were exhibited during which the head was raised and dashed forcibly on the ground, the membranae being drawn over the eyes as in tetanus. These fits were followed by periods of rigidity of neck and legs.

The animal died during a violent muscular spasm 26 hours after being dosed. Post-mortem examination, made immediately, revealed a very marked distension of stomach with gas, and a congestion of the mucous membrane. There was very pronounced hypostatic congestion of the right lung, and considerable oedema of the visceral pleura. There was an excess of pleural fluid. The heart was normal.

6. Tests on Small Laboratory Animals.

(1) *Guinea Pigs.*—In an early experiment, a guinea pig which had voluntarily eaten a very small quantity of the bark of a vine died the following day. In subsequent tests on four guinea pigs, however, weighed doses of 5 and 10 grams failed to produce any ill effects.

(2) *Rabbits.*—5 grams of minced vine produced no ill effects in an adult wild rabbit; 10 grams of minced vine produced death in a similar rabbit within 24 hours, post-mortem examination revealing nothing striking apart from distension of stomach and intestines with gas.

(3) *Fowls.*—A fowl was given 20 grams of minced vine in bolus form. Six hours later, the bird was lying on its side alternating between periods of calm and excitement, manifested by violent kicking of the legs. The head and neck were drawn backwards. The membranae nictitans were constantly moved across the open eyes. The bird died approximately twelve hours after receiving the plant material, post-mortem showing no striking abnormality.

7. Tests on the Toxicity of Extracts.

Two extracts were prepared and kindly made available to us by Mr. H. Finnemore, Sydney University, and Chairman of the Poison Plants Committee, which is functioning under the aegis of C.S.I.R. He states that the plant does not contain alkaloids, or cyanogenetic glucoside. The extracts were :—

(*a*) Petroleum ether extract.

(*b*) Alcoholic extract.

Mr. Finnemore described the method of making the extracts as follows :— The plant was exhausted with alcohol, the solvent recovered and the resulting extract treated with petroleum ether. The part which dissolved in petroleum ether is called the "petroleum ether extract." The part extracted by alcohol, but which did not dissolve in petroleum ether, is referred to as the "alcoholic extract."

Alcoholic Extract.—Sheep 12 received 8 grams of the alcoholic extract, dissolved in 100 c.c. of water. (This represented the yield of alcoholic extract from 4 ounces of vine.) Twenty-one hours afterwards, the animal was lying down on its side exhibiting the characteristic symptoms—paddling movements, tympany of rumen, muscular spasms, with opisthotonos, laboured respirations, and grunting, grinding of the teeth, and profuse salivation. It was killed 32 hours after dosing and post-mortem examination was made immediately. The rumen and intestines were greatly distended with gas. The mucous membrane of the abomasum and that of the small intestine were much congested. The heart showed considerable subendothelial spotting, in both left and right ventricles.

Petroleum Ether Extract.—Sheep 13 received 5.6 grams of the petroleum ether extract in bolus form. (This represented the yield of petroleum ether extract from 4 ounces of vine.) No ill effects followed.

Sheep 14 received 28 grams of petroleum ether extract. The animal became somewhat uneasy six hours later, and distinct tympany was noted, but the following morning it appeared quite normal. No subsequent ill effects occurred.

8. Discussion.

Discussion.—Apart from a little endothelial poison, as shown by the pleural and pericardial exudates and the epicardial ecchymoses, and the paralysis of the stomach and intestines, no other obvious pathological changes are noted on post-mortem examination of the poisoned animals. There is a complete absence of local effects in the alimentary canal. The poison evidently acts chiefly on the central nervous system, giving rise to inability

to stand without, however, complete paralysis, for vigorous and co-ordinated leg movements invariably exist. The stretching backwards of the neck and head and the clenching of the jaws indicate an irritation of the spinal nervous centres concerned. The presence of the corneal light reflex and the usual response to cutaneous stimuli indicate an absence of any narcotic principle in the plant. The rise in body temperature may be taken as a consequence of the violent and prolonged muscular effort during spasms. The salivation may be due to inability to swallow or to some active principle in the plant.

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The Occurrence of Green Pus in Suppurative Lesions of the Sheep.*

By H. R. Carne, B.V.Sc., Lecturer in Veterinary Pathology and Bacteriology, University of Sydney.

(From the Pathological Department of the McMaster Animal Health Laboratory.)

The opinion appears to be commonly held that the greenish colour of the pus and caseous material in lesions of caseous lymphadenitis of sheep is a distinctive character of *Corynebacterium ovis* (or the bacillus giving rise to caseous lymphadenitis and also known as the Preisz-Nocard bacillus).

In the course of our investigations, we have had occasion to investigate this assumption.

Our attention was first drawn to the greenish caseo-purulent material, which is constantly found in young lesions in the bowel wall, caused by larvae of *Oesophagostomum columbianum* in sheep. It was thought that this greenish coloration might be due to the association of *Corynebacterium ovis* with the lesions caused by these larval nematodes. However, direct microscopical examination of the caseous material from a large series of such lesions in naturally infected sheep, together with cultural tests, failed to demonstrate the presence of *C. ovis* in any instance. Most of the lesions examined were found to be sterile, but where bacteria were recovered, they proved to be Gram negative intestinal bacilli.

In a further large series of lesions of oesophagostomiasis experimentally produced in sheep, where large doses of culture of *C. ovis* were administered immediately after drenching with *Oesophagostomum* larvae, association of *Corynebacterium ovis* with the lesions of oesophagostomiasis could not be demonstrated (H. R. Carne and I. Clunies Ross, this *Journal* 1930, Vol. 4, No. 2, pp. 78–80.)

On several occasions we have examined lesions in sheep, which proved to be sterile, but which showed marked green coloration of the caseo-purulent contents. One of these was an aseptic area of caseous degeneration situated in a mass of necrotic tissue in the spermatic cord of a ram, resulting from thrombosis, following marked varicosity of the spermatic vein.

Again, the same greenish colour was observed several times in necrotic testicular tissue which had been implanted aseptically in rams in which certain experiments on rejuvenation were being carried out.

The following experiment brought conclusive evidence that green pus is not produced only by *C. ovis.*

A series of six sheep were inoculated subcutaneously in the thigh as follows:—

Sheep 1.—Serum broth culture of *Corynebacterium ovis.*

Sheep 2.—Serum broth culture of *Bacillus pyogenes,* isolated from a sheep.

* Since writing this note, our attention has been drawn to an article by J. A. Gilruth, in the Report of the New Zealand Department of Agriculture, 1901-2, p. 269. It was suggested that the green coloration of pus in caseous lymphadenitis is not due to any chromogenic action of the part of the causal bacillus, but rather to the reaction of the ovine system. In the same report are described purulent lesions of the pleura and peritoneum of the sheep, and a case of pulmonary actinomycosis in a sheep, in which greenish pus was present.

Sheep 3.—Serum broth culture of *Bacillus pyogenes* isolated from a cow.

Sheep 4.—Serum broth culture of *Actinomyces bovis* (Wolff-Israel type).

Sheep 5.—Broth culture of *Staphylococcus pyogenes aureus.*

Sheep 6.—Turpentine.

In sheep 1, 2, 3, and 4, subcutaneous abscesses developed at the sites of inoculation, which were filled in each case with green pus, which was indistinguishable in appearance. In sheep 5, green pus was also present in a small abscess, but was considerably less in amount and paler in colour than in the previous four sheep. Sheep 6 was inoculated with turpentine, and showed an oedematous, watery lesion with a definite greenish zone round the margin. In sheep 1 to 5, it was found that the organisms were present in the lesions in a state of purity.

It is our opinion that green is the usual colour of pus in the sheep, irrespective of the cause of suppuration. In several cases, however, we have inoculated sheep with pure cultures of certain organisms from actinomycotic lesions in cattle, and produced a very thick mucoid type of pus with only a very faint, scarcely perceptible, green colour.

It is interesting to note here the different colour of the pus produced by certain bacteria in different animals. For example, suppurative lesions produced by *Bacillus pyogenes* in sheep and cattle usually have a definite green colour. This organism in the rabbit, however, produces a pus that is almost white. Again, *C. ovis* produces green pus in the sheep, but when inoculated subcutaneously into cattle, produces a thick mucoid pus which is yellowish-white.

Several attempts have been made to extract the green colouring matter from pus. Some of the material was rubbed up with plaster of paris until it became a dry, crumbly mass. This was then shaken up with ether. No colour could be extracted in this way, indicating that the pigment is not carotin.

Distilled water, ethyl and methyl alcohols, ether, chloroform, and acetone were all tried as solvents with no success.

Conclusions.

1. Greenish coloration of suppurative lesions in sheep is not a specific characteristic of *Corynebacterium ovis.*

2. Green pus was produced in experimental lesions resulting from inoculation of *Bacillus pyogenes, Actinomyces bovis,* and *Staphylococcus aureus.*

3. Green pus may be formed in sterile lesions.

4. The opinion is expressed that the usual colour of pus in the sheep is green, irrespective of the cause of suppuration.

5. Efforts to extract the colouring matter from green pus were unsuccessful.

The Buffalo-Fly in Australia.

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Introduction.

The object of this paper is to give a short account of the buffalo-fly (*Lyperosia exigua* de Meijere) in Australia, with special reference to the work done by the Council for Scientific and Industrial Research on the problem.* It is not intended as a full record of the various lines of research which have been undertaken by the Council on this problem, but rather as a general account of the results of these researches to date, on broad lines. It is hoped that, by means of this paper, the Australian public may be enabled to grasp the actual position which Australia has to face to-day as the result of the unfortunate accidental introduction of this pest many years ago.

1. Historical.

The buffalo-fly (*Lyperosia exigua* de Meijere) is a small biting fly whose original home is the Indo-Malayan Region. It is closely related to but distinct from the horn-fly (*Lyperosia irritans* Linnaeus), which, originating in Europe, has become a serious pest in North America and the Hawaiian Islands.

There can be no doubt that the buffalo-fly originally entered Australia by way of Melville Island at the time when the first buffaloes were introduced there. This was as early as 1825. In 1838, buffaloes were brought to the mainland of Australia at Port Essington in the Coburg Peninsula, and with them, the fly. With the development of the pastoral industry in Northern Australia, the buffalo-fly entered on its career as an important factor in the economic life of the country. It was not, however, until 1912 that it came under official notice, the first published record of its occurrence having been made by Dr. J. A. Gilruth when Administrator of the Northern Territory; this record was accompanied by a note by Mr. Henry Tryon, at that time Government Entomologist of Queensland, who identified the specimens submitted to him. Mr. G. F. Hill, when Entomologist in the Northern Territory, referred to the fly several times in the Reports of the Administrator from 1912 to 1916, and in 1917 gave a short but excellent account of its life-history and habits, adding further observations in a second paper in 1923. A list of other Australian references to the fly is given at the end of this paper; the Division of Economic Entomology also possesses a number of valuable unpublished reports, notably those of Tryon (1920), Gilruth (1922), Sweet (1926), Murnane (1927), Nieschulz (1928), and Smith and Clegg (1929). There are also numerous mentions of the buffalo-fly in reports of meetings of various Pastoralists' Associations and a considerable amount of publicity has been given to the problem in the press.

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2. Plan of Division's Researches.

With the formation of the Division of Economic Entomology in 1928, a definite plan of research on the buffalo-fly problem was drawn up as one of the major activities of the Division, and was entrusted to Dr. I. M. Mackerras as senior entomologist in charge. The basis of this plan was two-fold ; firstly, the recognition that biological control of the fly by means of its natural enemies offered the only possible method of controlling the pest in areas where it already existed ; and, secondly, that a very thorough comparative study of the life-history and habits of the fly in the two contrasted regions of Northern Australia and the Netherlands Indies was essential before any insect likely to be beneficial could be introduced.

The administration of measures of control or of preventing the spread of the pest, though they may be based on scientific work, is not primarily the concern of the Council, but it was early made clear that those authorities who are charged with this duty would look for much information and advice from the Council, particularly with regard to surveys of the spread of the fly itself. Thus an important aspect of the work has been the determination of the actual area occupied by the fly, and also the estimation as to what its future movements were likely to be.

Investigations in Northern Australia were begun by sending Mr. T. G. Campbell to Burnside Station, Brock's Creek, in March, 1929. Subsequently, through the generosity of Mr. L. McGhie, General Manager of the Wyndham Meatworks, an excellent laboratory was provided at Wyndham, and Mr. Campbell was transferred to that centre. On his return from Java in 1929, Dr. Mackerras accompanied Mr. Campbell from Darwin through to Derby in North-Western Australia. Mr. Campbell has carried out surveys and field-studies over practically the whole area of country infested by the fly, with very valuable results. Later (1931), owing to unfavorable seasons for the fly at Wyndham, the Australian part of the work was once more transferred back to Burnside, and Mr. Campbell has been relieved by Mr. H. J. Willings.

The work of this Division in the Netherlands Indies was begun in May, 1929, when Dr. Mackerras and Mr. G. L. Windred were sent to Java to make a preliminary survey. These two officers in June and July, 1929, made a tour of the Lesser Soenda Islands from Java to Dutch Timor, making observations on the abundance of the fly and the occurrence of its parasites. Dr. Mackerras then returned to Australia, while Mr. Windred remained in Java, where he was provided with excellent laboratory facilities through the kindness of Dr. C. Bubberman, Director of the State Veterinary Institute at Buitenzorg. Working from Buitenzorg as centre, Mr. Windred has made observations in many parts of Java and has greatly added to our knowledge of the fly. Professor E. Handschin, of the University of Basle, Switzerland, appointed to take charge of the investigations in the Netherlands Indies for a period of two years, arrived in Java in November, 1930, and took over the work there, with Mr. Windred continuing as his assistant.

3. Summary of Life-history and Habits of the Fly.

Hosts of the Fly.—In the Netherlands Indies, the adult buffalo-fly feeds on the blood of cattle, including zebus and other races of native cattle, and buffaloes, but not, as far as is known, on any other animals. In Northern Australia, the fly attacks buffaloes, cattle of all kinds, horses, mules, donkeys, and occasionally man himself.

Under natural conditions dogs, pigs, goats, sheep, and rabbits are not attacked, nor are the native marsupials such as kangaroos and wallabies.

In the case of cattle, it has been observed both in Java and Northern Australia that the fly prefers bulls to bullocks or cows, and that it also shows a preference for individual bullocks over others. This individual preference is frequently associated with the age or condition of the host, but the reasons for it are not always clear.

Effect on the Hosts.—The buffalo-fly is not a disease carrier, nor does it directly cause the death of its host by the severity of its attacks. But it does produce a serious loss of condition, due to "fly-worry." The animals are kept continually on the move, when they should be feeding quietly. Large sores are produced by rubbing against trees, white-ant nests and so on, and septic absorption takes place.

When a beast becomes used to fly attack, it can stand a considerable concentration of flies without losing condition. Our observations suggest that a concentration of somewhere about 1,000 flies per beast is the critical point. Below this, there is little or no loss of condition. Above it, the fly is a definite economic pest. In Northern Australia, our workers have found concentrations of from 2,000 up to as much as 5,000 per beast; at such a level of abundance, the loss of condition is very great. It is clear that in this case the amount of economic loss is directly due to the abundance of *adult* flies. This fact has a most important bearing on the question of biological control and will be treated more fully in Section 7.

Life-history and Habits.—The *Adult Fly* is a rather slender, grey insect, about half the size of the common house-fly and markedly smaller than the bush-fly, from which it is easily distinguished by its much duller colouring. When resting on cattle, it can be recognized by its habit of holding its glistening wings projecting upwards at an angle from the surface of the animal. The most striking feature of the fly is its proboscis, which forms a rigid, stiletto-like tube 1.0 mm. long, somewhat swollen at the base; this is forced through the skin like a hypodermic needle. A pair of finger-like palps lie alongside the proboscis, giving it a somewhat distinctive appearance.

Plate 5, Fig. 1, gives a very good representation of the fly with its transparent wings outspread.

As stated above, buffalo flies are blood suckers. They can absorb other fluids, but are incapable of swallowing solid material, such as the "scurf" on the skin. Krijgsman and Windred (1930) have studied the factors attracting the flies to the hosts on which they feed. These authors find that the odour of the host, the warmth of its body, and water vapour from the sweat all play an important part. The influence of water vapour is so strong that flies are attracted in the laboratory to green leaves, which they pierce and suck. It is possible that in this way they may be able to prolong life somewhat in nature, in the absence of hosts. A feed of blood, however, appears to be necessary before the eggs can mature. Other factors influencing the activity of the adult flies are intensity of light, wind direction, the roughness of the surface on which they rest, and especially temperature and humidity. Campbell has shown that a drop of temperature below 70° F. induces sluggishness, and a drop to 40° F. renders the fly comatose. A wet bulb temperature below 60° F. has a markedly unfavorable effect on the fly.

The flies remain on their hosts for long periods, up to ten days or more, feeding intermittently. They pair on the host, and when dung is dropped, the females leave the host, quickly lay their eggs in the dung and return to the host within a few seconds. Krijgsman and Windred (1931) have found that the specific odour of the dung is the most important factor in

attracting the flies and that the female flies are more strongly attracted than the males. They found also that the dung of the buffalo is more attractive than that of cattle, that the latter is markedly more attractive than that of horses, and that the dung of carnivorous animals is not attractive. Eggs are only laid in fresh dung, and any type of droppings which ages or dries out rapidly is neither attractive to the fly nor suitable for the development of the maggots.

The *eggs* are about 1.13 mm. long, slenderly oval, creamy-yellow in colour. In warm weather they hatch in about 20 hours. They are rapidly killed by drying, and cold weather arrests their development. Thus, the greatest rate of increase of the flies is always to be noted a little after the onset of the wet season.

The *larvae* or maggots (Plate 5, Fig. 2), when full grown, are superficially very much like those of the common house-fly, but not so large. They are about 6 mm. long, are creamy-white in colour, and tapering towards the head end. The most favorable conditions for growth appear to be a moist atmosphere and a temperature of from 80° to 85° F. Under such conditions, larval life is completed in about four days. Higher temperatures than this are unfavorable to larval growth, and lower temperatures tend to increase the length of larval life very greatly; at a range of from 40° to 60° F., the larval life is four weeks.

The food of the larvae consists of dung in a moist condition; experiments indicate that about 68 per cent. saturation with free water is most suitable for them. Larval development is seriously interfered with when the amount of free water falls far short of, or rises well above, this point; at saturation point, and again at below 50 per cent., the development of the larva ceases. Thus, as a heap of dung dries up slowly from the outside inwards, the larvae are found to work their way steadily into the moister layers.

The *puparium*, or resting-stage, during which the soft pupa is formed within the hardened outer larval skin, is of the usual barrel-like form, bright reddish-brown in colour, about 3 mm. long, and may be found either under old heaps of dung or in the soil near by. Puparia require less moisture than larvae; under wet conditions they suffer from the attacks of bacteria, and they are also rather sensitive to too much dryness. Low temperatures prevent the hatching of the fly from the puparium, but at any rate a certain proportion of the puparia will hatch when the temperature rises again. The most suitable temperatures for the puparia appear to be about the same as those for the larvae.

Most Suitable Country.—It will be clear from the above account that the fly will thrive best in Australia in districts possessing a hot, humid climate, and that, except in extremely wet weather, it will breed most abundantly in low-lying, moist areas, and more especially around the margins of waterholes and billabongs.

4. The Position in North-Western and South-Western Australia.

Starting from the Coburg Peninsula in about 1838, the general movement of buffaloes and also of the fly travelling with them was to the south-westwards. With the development of the pastoral industry, the fly attached itself to cattle and spread steadily all over the settled portions of the Northern Territory north of the 20-inch rainfall line. The spread was more rapid towards the west than towards the east, owing to the greater development of the cattle industry in that direction. Probably by 1910, the fly had reached the Kimberley district. For many years past, it has

been the major pest of cattle in that region, and figures supplied by Mr. L. McGhie, General Manager of the Wyndham Meatworks, are eloquent testimony of the effect on the value of their product, due to the loss of condition caused by the attacks of the fly in bad seasons.

Reference to Map 1 (Plate 4) shows the present limits of extension of the fly. The visit of Dr. Mackerras and Mr. Campbell to the North-west in 1929 served to show that a slight extension had taken place, since previous records, along the southern bank of the Fitzroy River and down the coast to Anna Plains; but, on the other hand, owing to three years of relatively light rainfall, there had also been a regression of the area occupied by the fly in other districts.

It can now be stated that the buffalo-fly has just about reached its limit of extension in this region. Southwards from it lies a wide region of extremely low rainfall, the area receiving less than 10 inches annually including a wide stretch of coastline between North-West Cape and Edel Land. The buffalo-fly cannot pass this area by natural means. South-Western Australia, therefore, is protected from invasion by this pest by a most efficient natural buffer-area. The danger to the rich dairying districts of the South-west and to the metropolitan district of Perth and Fremantle lies in uncontrolled export of cattle by sea from the port of Derby to Fremantle. In 1928, the fly was actually detected at Fremantle, and stringent measures were taken for its eradication, including the prohibition of the landing of manure from the cattle-boats for the use of the Fremantle market-gardeners. Still further measures of control are now in operation, the cattle being run through a spray-race at Derby Jetty before being embarked, and again, if necessary, treated similarly on being landed at Robb's Jetty at Fremantle. Various spray mixtures have been tested in this connexion. The very effective one at present in use contains a strong base of eucalyptus oil, which is found to act as a repellent to the fly for at least 24 hours.

From the port of Broome, small and irregular shipments of cattle are made to the south, but mostly during the dry season. The rainfall at Broome being relatively low, and the port lying only just inside the area occupied by the fly, the danger of carrying it southwards is not great, and is considered to be adequately met by careful inspection of shipments and by spraying on arrival at Fremantle if necessary.

Mr. L. Newman, Government Entomologist of Western Australia, states that he succeeded in rearing two generations of buffalo-fly through to maturity from the material originally taken at Fremantle. This is sufficient proof that the fly could thrive and spread in the Perth district, if it ever got a secure footing there. This fact has to be taken into account in our attempt to fix the probable limits of the fly in Eastern Australia.

5. The Position in North-Eastern Australia.

In the previous section, with the aid of Map 1, the spread of the fly was followed from the Coburg Peninsula westwards. In the same map the gradual spread of the fly at a somewhat slower rate to the eastwards is indicated. For more than 100 years after the first introduction of buffaloes into Melville Island, the eastward spread was confined to the Northern Territory. Much of the country colonized by the fly during that period carried relatively few cattle, and the general movement of such cattle was either towards Darwin or to Queensland across the elevated, dry country of the Barkly Tableland. There was very little movement along the coast towards Queensland in country which is favorable to the fly. As, however,

obtained a footing in areas where the movement of cattle was towards Queensland in the favorable coastal country, the annual rate of spread increased, especially when it reached more heavily stocked country. The fly was common on the Roper River in 1911 ; by 1926 it was as far east as the Robinson River, only about 70 miles west of the Queensland border. The first record of the fly in Queensland itself was made by Smith and Clegg in October, 1928, at Westmoreland Station, 12 miles east of the border line. In September, 1930, Campbell recorded a further eastward advance to Turn-off Lagoons, an extension of 58 miles in a little under two years. The latest survey by Dr. Mackerras, Mr. Campbell, and officers of the Queensland Department of Agriculture and Stock, in June, 1931, places the most easterly limit of infestation at Augustus Downs Head Station, well east of the Leichhardt River, an extension of 96 miles in less than nine months. This rapid eastward movement was assisted by a favorable wet season, but was chiefly due to movements of horses and cattle in the area. The eastward limits of the pest as determined by the last survey are indicated in Map 2, Plate 5.

It is necessary to stress here the importance of the discovery in the course of this last survey, that the fly had succeeded in colonizing Mornington Island in the Gulf of Carpentaria. The nearest point of this island is distant 19.5 miles from the mainland, with intervening uninhabited islets. There is a Mission Station on the island, and accurate records are kept of the movements of men, cattle, and horses. From these it is certain that the last stock to be shipped across was a yearling bull in April, 1929. Buffalo-flies first appeared on the island at the end of 1930, during the height of the wet season, and by March, 1931, they were a serious pest. It is quite certain that they reached the island by flight, favoured by a strong south-westerly gale, such as was recorded twice during that season. As the part of the mainland closest to the island is unoccupied, and the nearest point where cattle are likely to occur is on Cliffdale Creek, it seems highly probable that the fly made an unaided journey of some 32 miles rather than 20 miles. This fact is of the utmost importance in considering the question of buffer-areas. Such areas are discussed at some length in the report of the recent survey by Dr. Mackerras and Mr. Campbell (see this *Journal*, August, 1931, p. 194).

In studying Map 1, emphasis must be laid on the importance of the 20-inch rainfall line. This line marks approximately the southward spread of the fly ; it may fluctuate about this line, and may extend occasionally beyond it, especially along river-beds ; but, generally speaking, it has not entered into permanent occupation of territory lying outside it.

Elevated territory with a low rainfall, such as the Barkly Tableland, forms a natural barrier to the fly. It has repeatedly been observed that the fly disappears from cattle when they reach this tableland.

As regards the movements of cattle from Northern Australia into Queensland, it is clear that the fly travels readily along the coastal route. The inland routes, by way of Lake Nash and Camooweal, can be regarded as safe owing to climatic limitations.

6. Probable Limits of Spread of the Fly.

Plate 6, Map 3, shows the probable limits of spread of the buffalo-fly into Eastern Australia if present efforts to prevent its advances are ineffective. These limits have been determined as follows :—

(1) *Rainfall.*—Observations over large areas of country in North Australia indicate that a 20-inch rainfall is about the minimum that the fly can tolerate. Hence the 20-*inch line of average*

annual rainfall sets an approximate boundary over which the fly will not pass very far. Oscillations may be expected to occur across this line, the fly extending its range temporarily in exceptionally wet and favorable seasons and then retreating again during dry periods. Maximum penetration into the drier areas may be expected to take place along river-valleys.

(2) *Temperature.*—Observations made in elevated country, during periods of cold weather, and in the laboratory indicate that the fly is not likely to be completely killed out except by heavy frost. These observations are supported by the fact that Mr. L. J. Newman succeeded in breeding the fly in May at Perth, Western Australia. As the whole of the coast-line of Eastern Australia has an average annual rainfall well in excess of 20 inches, it is, therefore, clear that, once the fly reaches the Queensland coast, it will travel steadily southwards, probably as far as the Hunter River in New South Wales.

The only areas in the shaded portion of the map which might be expected to escape would be highly elevated country in which winter frosts were sufficiently severe to kill the puparia of the fly. Portions of the Dividing Range, such as the New England Tableland in New South Wales, and possibly the Darling Downs in Queensland, might escape for this reason; these areas are shown by broken shading in the map. The Atherton Tableland in Queensland, though elevated, has a considerably higher average annual temperature than those mentioned. It seems probable that the fly could establish itself on this tableland, which is, therefore, included in the fully shaded area. The fly may be expected to be a pest over the greater part of the shaded area, but towards the limits of infestation and in country approaching 2,000 feet elevation, it is not likely to be serious.

It is clearly shown on the map, and it is a most significant point, that the probable area of infestation includes the best beef raising and some of the best dairying country in the whole of Australia.

7. Biological Control.

(*a*) *The General Problem.*—Naturally, the first effort in any comprehensive scheme of buffalo-fly research must be directed towards the discovery of an effective method of biological control. Biological control can never prevent the spread of a pest, owing to the fact that the pest population can never be reduced to zero and there is thus nothing to prevent the fertilized female from passing beyond the boundary of infestation. The ideal natural enemy would be one which was itself the primary cause in limiting the abundance of the fly. A natural enemy of this type is essential for the solution of a number of problems in economic entomology. In the case of the buffalo-fly, however, all that is needed is to reduce the number of active *adult* flies to a point at which no appreciable harm will be caused to the cattle. It follows from the above considerations that it is well within the bounds of possibility that a single parasite, or a group of parasites, or perhaps a combination of parasites, predators, and dung competitors might be found which would reduce the numbers of the fly in Australia to a point below pest abundance. As already stated in this paper, the fly becomes of definite economic importance when its numbers reach about 1,000 per beast. There are many parts of North Australia where this number is not greatly exceeded

even in the wet season. Therefore, in such areas, a relatively small reduction by means of natural enemies might be of appreciable economic value.

As the wet season is the period of greatest abundance of the fly, it is clear that we must seek for a parasite, or combination of parasites and other types of natural enemies, which will operate principally during the wet season. This would be the ideal type of biological control to be aimed at. Failing this, the next best type of control would be one which would shorten the annual period during which the fly could operate effectively, thus giving the cattle a chance to recover condition before the dry season set in again.

It is also important to note that the most effective parasite in reducing the numbers of the adult flies would be one which attacked and killed the pupa. It so happens that this is exactly the type of parasite which is found most commonly, and this type is also the easiest to handle in the laboratory and in the field.

A further interesting point is that we already know of certain insect competitors in dung which are in themselves perfectly harmless, both as larvae and as adult flies. The introduction of a vigorous competitor of this type into Australia might have very beneficial results, and is well worth attempting. A similar type of control by the use of competitors is now being attempted in Fiji against the house-fly.

(*b*) *Work in the Netherlands Indies.*—At the request of the Council, and following reports obtained from Dr. Georgina Sweet and other sources, an investigation was carried out in the Netherlands Indies by Dr. Otto Nieschulz. a member of the staff of the Veterinary Institute, Buitenzorg. This work was carried out in 1927, but unfortunately no very detailed report has ever been received from Dr. Nieschulz, and the parasites which he discovered still pass under the labels which he affixed to them, viz., BzA, BzB, BzC, and BzD. As his work was carried out at Buitenzorg, the prefix "Bz" was used by him to indicate parasites discovered there.

In drawing up the plan of work for this Division, it was clear that the work begun by Dr. Nieschulz in Java should be proceeded with much more vigorously. Also, since it was evident that the buffalo-fly is not a pest of any importance in most parts of the Netherlands Indies, though it occurs throughout all the Islands, it was clear from the outset that an answer to the problem as to why the fly was such a pest in Northern Australia ought to be found through an investigation in the Netherlands Indies. This great chain of islands has extremes of climate ranging from excessively wet to dry. It is therefore probable that rainfall is not the only determining factor for buffalo-fly abundance. Parts of Timor appear to have conditions of climate and soil closely approaching those of the Kimberley region in North-West Australia. Obviously, therefore, our survey of the problem must be extended ultimately to Timor.

The Division's work in the Netherlands Indies began with the survey carried out by Dr. Mackerras and Mr. Windred in May, June, and July, 1929. This survey extended from Java through the Lesser Soenda Islands as far as Koepang in Timor, thence back to Java. Buffalo-fly was found everywhere. Generally speaking, its incidence was low, nearly always under 200 flies per beast, and frequently only from five to ten. Many kinds of native and European cattle are found in this area, and all of them are subject to attack by buffalo-fly; hence it is evident that the severity of the attack in Northern Australia is not due to the particular breed of cattle there. Despite the great variations in climate throughout the chafn

of islands, no correlated differences in local abundance were observed. Moreover, subsequent observations have not revealed seasonal changes in abundance of the magnitude that occurs in Australia. Certain extreme local fluctuations of a more or less sporadic nature were discovered in restricted localities, and these are being closely studied with a view to discovering their causes. It is as yet too early to say whether any relationship exists between parasite abundance and these peculiar local variations.

As a result of Windred's work, the number of known parasites of *Lyperosia* was considerably augmented, the total being raised to twelve species. Nieschulz's work indicated that the species of *Spalangia* which he labelled "BzC" was easily the most promising and abundant of his four species. The later survey by Mackerras and Windred has fully substantiated this, for "BzC" was found in more localities than any other species, and extends from Java right through to Timor. It has also been reared from puparia of species of *Musca* and *Chrysomyia* as well as from *Lyperosia*.

Professor Handschin has isolated a special strain of the parasite "BzC" on *Lyperosia* puparia, and is also crossing this parasite with the species of *Spalangia* discovered in Northern Australia, with a view to studying the characters of the various hybrids evolved from the cross. Introduction into Australia of the most suitable types of parasites will be made in April, at the end of the wet season.

(c) *Plan of Campaign for Biological Control.*—The basis on which the plan of campaign for biological control of buffalo-fly in Australia is laid down may be stated as follows:—

(1) It is recognized that no parasite or combination of parasites can ever eradicate the buffalo-fly from Australia.
(2) The aim of the work is to reduce the incidence of the fly attack below the average level at which the fly causes economic loss to the cattle industry.
(3) Therefore it is essential that the best possible parasite or combination of parasites should be tried out.
(4) It is also essential that the parasites, when introduced, should be bred in large numbers and distributed at strategic points.

In order to carry this plan out, it is proposed to base operations on two points, viz., Burnside Station in North Australia, and a suitable locality near Burketown in Queensland. The principal work at Burnside will be to establish the parasites and rear them in large numbers for distribution, firstly to selected points in North Australia, and secondly to Queensland. In connexion with the station in North-Western Queensland, work will also be carried out on Mornington Island, which is easily reached by launch from Burketown. The infestation of buffalo-fly on this island is severe, and therefore offers an excellent opportunity of testing the usefulness of any introduced parasites.

The general aim of the biological control work is to secure the establishment throughout the infested territory of the best possible combination of parasites of the fly. Combined with the most suitable measures for preventing the rapid spread of the fly into Queensland, this offers the most practical method available for controlling the pest.

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Radio Research Board: Annual Report for Year ending 30th June, 1931.

The Radio Research Board of the Council is constituted as follows:—Professor J. P. Madsen (University of Sydney), Chairman, Mr. H. P. Brown (Director-General, Postmaster-General's Department), Electrical-Commander F. G. Cresswell (Department of Defence), and Professor T. H. Laby (University of Melbourne). Its previous annual report appeared in this *Journal* (Vol. 3, No. 3, August, 1930).—Ed.

1. General.

Work on the programme outlined in previous reports has been continued. The survey of the field strengths surrounding the two higher powered stations of Sydney (2FC and 2BL), however, has been completed, and thus the investigations in progress now relate to two main matters, viz., fading and atmospherics.

Throughout the year, the Board has closely scrutinized its expenditure from time to time with a view to ensuring that the work being undertaken is of such a nature as fully to justify its continuance under the existing financial conditions of the Commonwealth. In accordance with this policy the Board has materially reduced its estimates for the financial year 1931–32. In particular, appreciable savings have been made in the amounts allocated under the original scheme to the purchase of equipment. The Departments of the Universities of Sydney and Melbourne have also helped in this connexion and have so arranged matters that maintenance charges incurred by the investigators will not be as large as originally allowed for.

Towards the end of the period under review, the Board suffered a serious loss in personnel owing to the resignation of one of the investigators stationed at Sydney (Mr. W. G. Baker). It has also been notified by another of the Sydney investigators, Dr. L. G. H. Huxley, that he intends shortly to resign*. For the time being, the vacancies will not be filled. There is little reason to doubt that one of the important considerations leading to these resignations was not any lack of attractiveness in the work itself—far from it—but the fact that the investigators allocated to the Board cannot, under the existing system of its financing, be offered any security of tenure. The same considerations apply to radio research as to any other form of research, namely, that no organization can expect to retain high-class investigators for any lengthy period unless it can offer them some degree of freedom from anxiety as to their future.

2. Field Strength Work.

The results of the field strength survey around Sydney, mentioned in the previous section, have been published as the Council's Bulletin 47, which also contains a paper dealing with corrections to field strength measurements with loop antennae. In the latter paper, the theory of the loop antenna is considered on the assumption of uniformly distributed capacity and the ordinary transmission line theory applied. It is shown that in measuring loop resistance by the added resistance method, different results are obtained by adding the resistance at the centre or at the end of the loop. Voltages introduced into the loop at the centre or end have different effects for distributed voltages. In the application to field strength

* Dr. Huxley has now resigned as from the 4th September, 1931.

measurements, it is shown that in most cases a correction factor must be applied to the results depending on the ratio of tuning capacity to the self capacity of the loop. Tables of correction factors are given.

In the portion of the Bulletin devoted to the field strength survey, the development of a receiving set capable of measuring weak field strengths is described. In the survey itself, measurements were taken for roughly 100 miles around Sydney. The results obtained are given on a topographical map of the area covered and in the form of contours of equal field strength. Measurements were taken of the field strength of station 2FC working on a 451 metre wavelength and of station 2BL on 353 metres. For the most part, the contours of the two stations run approximately parallel to each other, but differences occur in places, possibly due to the fact that station 2FC is located several miles inland and 2BL is on the sea. For instance, the field strength of 2BL was found to diminish along the coast to the south of Sydney at a less rate than does that of 2FC. Other information of interest in connexion with the location of transmitting stations, e.g., the attenuating effect of wooded hills, is quite apparent from a study of the map.

3. Work on Fading and the Heaviside Layer.

The investigations on fading and on the various properties of the Heaviside layer in the Southern Hemisphere have been continued in both Victoria and New South Wales. This work is of a fundamental nature, but it is quite promising from the point of view of the improvement of the wireless services of the Commonwealth. Were it possible only to reduce the fading which occurs so annoyingly in the country districts of Australia the investigations would be justified, but they may quite easily lead to information of even greater value.

(*a*) *Work in Victoria.*—In the previous annual report, it was indicated that one of the Melbourne investigators (Dr. Martyn) had evolved a new method of measurement of the Heaviside layer heights which possessed some advantages over other methods. The principle of the new method is as follows:—If the carrier wave of a wireless transmitter be increasing steadily in frequency, then a given receiving station will in general pick up two waves which differ in wavelength. One of these waves will have reached the receiver by the shortest path along the ground, while the other will arrive after having suffered reflection at the Heaviside layer. After rectification, these two waves will give rise to a beat note in the receiver. It is possible to arrange that this note shall have an audible pitch, and a determination of the latter may be used to obtain a measurement of the height of the layer. The resulting method possesses some advantages such as simplicity, and it is also adapted to the obtaining of continuous records. In practice, it is not possible to continue increasing the carrier frequency indefinitely, but this difficulty is overcome by alternately increasing and decreasing the frequency many times a second, the rate of increase being constant and equal to the rate of decrease. It is evident that, corresponding to the change over from increasing to decreasing frequency at the transmitter, there will occur at the receiver a short period during which the frequency of the beat-note decreases rapidly to zero and rises again to its former value. The duration of this period must be made small compared with the time during which the beat note remains steady. This condition is satisfied in practice by ensuring that the time during which the carrier frequency is increasing (or decreasing) shall be large compared with the time difference of the two ray paths.

In order to test this method, a wireless transmitter of 250-watts power has been installed in the Natural Philosophy Department of the University of Melbourne which is accommodating Dr. Martyn. It has been equipped with automatic gear so that it will start up at specified intervals, and run for, say, ten minutes at a time. This enables the observations to be carried out by one observer only, located some miles away, and is of some importance since much of the work is carried out during the night. Safety devices are attached to the transmitter so that it will close down should a fault develop. The changes of frequency, or "wobbles" are obtained by the use of a small rotary condenser in parallel circuit with the principal condenser in the oscillating circuit, and driven by an electric motor of constant speed. Amplitude modulation is eliminated by suitable adjustment of the tunings of the aerial and oscillator circuits. The receiver consists of an ordinary wireless receiving set, with only a single tuned circuit, preceded by a band pass filter, thus enabling a flat-topped resonance curve to be obtained over the working frequency range of the transmitter.

Observations have been taken over distances ranging from 1 to 120 miles from the transmitter, and at all hours of the day and night. In general, the beat note is detectable only after sunset. It can be heard to fade quite quickly, and to vary gradually in pitch from moment to moment, thus indicating the undulatory nature of the Heaviside layer. For the taking of precise measurements, it is desirable to have some system of recording the frequency of the beat note, and a valve-frequency meter has been built for the purpose. It is further necessary to obtain a stronger signal from the transmitter with a view to getting a stronger "sky wave," and raising the strength of the beat note well above the general noise level. Steps are at present being taken to obtain a stronger signal with a view to the recording of the notes.

Recently a considerable amount of attention has been given to the analysis and interpretation of fading records taken in Victoria on 3LO and 3AR. These records were obtained simultaneously on a loop (or frame) aerial and on a vertical straight wire aerial, at distances from 35 to 120 miles from the stations. In general it has been established that most of the fading experienced can be analysed into two main types. There is usually a large slow fading cycle of, say, three minutes in period, while superposed on this, comes a smaller quick type of fading of, say, 20-seconds period. The first type of fading is attributed to an ionised layer at a height of about 100 km. and of relative stability, while the second type is to be associated with a considerably higher layer. It is possible theoretically to deduce the heights of the reflecting layer or layers from a consideration of the relative magnitude of the fading experienced on the two types of aerial system. When this method is applied to the slow fading, a layer of about 100 km. in height is found, but very erratic results are obtained if the method be applied to the fading of quick period. Possible explanations of this anomaly have been considered and experiments devised to test their validity.

While both types of fading are generally found in any fading record obtained during the evening hours, it sometimes happens that either the quick or the slow fading may be almost entirely absent. This is interpreted as indicating in the first event exceptional density and in the other event exceptional transparency of the lower layer. For example, quick fading only is found to be present in some of the early morning records, before dawn. As sunrise approaches, this gives place to slower period fading which finally ceases altogether soon after sunrise. The rates of movement

of the layers as deduced from the fading curves agree well with those measured directly by Mr. A. L. Green in Sydney, using the wavelength change method.

(*b*) *Work in New South Wales.*—During the period under review, Mr. A. L. Green completed the Heaviside layer work at Jervis Bay, mentioned in the previous report. In addition to a study of the height of the layer at various times, the angle of incidence of the sky waves as they reached the ground, the path of the normal component of the sky wave in relation to the abnormal component, and the polarization of the sky waves were studied.

The necessary wavelength changes were obtained from station 2BL and consisted of variations of approximately seven metres, the mean wave being the station's service one of 351 metres. The receiving site was on a flat just above the Naval College and was so located that the major portion of the ground wave between it and the transmitting station was over the sea. The experiments consisted of two series, the one taking place on four evenings per week from 10.30 p.m. till 11 p.m. and the other being one long test per week, usually beginning about three hours before sunrise and continued during the sunrise period. Originally the object of the evening experiments was purely in order to make tests of the apparatus so that an uninterrupted run on the more important early morning reception could be ensured, but it was soon found that they yielded important results in themselves.

As a result of the evening tests, it was found that the height of the layer was never very far from 110 kilometres (the work covered part of the winter, spring, and summer). The limits of the variations were 95 kilometres at the lowest and 150 at the highest. As the observations progressed, subsidiary effects were noticed, and ultimately it was possible to ascribe their cause to the existence of a second layer situated above the first and usually at about twice the height of the latter. This " F " region has been recorded also in England, but mainly in observations using shorter wave-lengths of the order of 100 metres. The inference to be drawn from the Jervis Bay work is that the upper layer is likely to be more important in Australia in its effects on the fading of broadcast signals than it is in England ; in fact some statistics compiled from the results of the above evening tests indicated that the " F " region was important as a cause of fading on about 54 evenings out of a total of 90 on which the tests were made, while it was the sole cause of fading on a further 23 evenings. Evidence was also obtained at Jervis Bay in support of the view that waves can be received after having been twice reflected at the one layer, the third point of reflection being at the surface of the earth midway between the sending and the receiving stations.

The sunrise experiments were carried out in order to study the layer at a time when the conditions in the upper atmosphere were steadier than at other times. The measurements of the polarization of the sky waves have provided interesting results from two points of view. Firstly it has been found by Appleton in England that the plane of the electric force in a sky wave is rotated in a counter clockwise direction by the action of the earths magnetic field. Theory indicates also that, in the Heaviside layer of the Southern Hemisphere, the rotation of the plane of polarization of a sky wave should be in a clockwise fashion, this difference being due to the dip of the earth's magnetic field being south in Australia and north in England. Such a right-handed rotation was actually found in the experiments at Jervis Bay, thus confirming in a very direct way one of the major points of the theory of the Heaviside layer.

The second reason for the importance of the above polarization experiments is to be found in the theory of some methods that are being investigated by the Board for the partial elimination of fading in certain cases. A knowledge of the state of polarization in Australia is essential to that work.

4. Work on Atmospherics.

As indicated in the previous annual report, the investigations on atmospherics are being carried out by means of two cathode ray direction finders obtained from the British Radio Research Board and of the type developed by that Board. One of these instruments is located at the Commonwealth Solar Observatory, Mount Stromlo, F.C.T., and the other at the R.A.A.F, depot at Laverton (near Melbourne). In addition an atmospherics recorder, also of the type used by the British Board, has recently been installed at Mount Stromlo.

For each direction finder, two frame aerials are used, one set in a north-south direction and the other in an east-west. The signals received in these aerials are amplified in the finder to the extent of something like 1,000,000 times their original strength. They are then applied to the cathode ray tubes in such a way that an atmospheric or a signal will produce a luminous line across the circular screen at the end of the tube. This screen is calibrated as a compass dial, so that the direction of the line on the screen indicates directly the direction from which the signal or atmospheric has come. In addition, its length on the screen is a measure of its intensity. As the radius of the screen is only 4 cms., the range of intensities measurable in this way is only at most from 1 to 8 for a given setting of the amplification, but by varying the sensitivity, the measurable intensity range can be increased to give a total range of from 1 to 1,000.

The arrangement of a cathode ray finder at each end of the Laverton–Mount Stromlo base line of 300 miles means that the source of any particular atmospheric can be determined, provided each instrument records the same disturbance. To ensure this simultaneous observation, an effective means of inter-communication is a necessity. In the previous report, it was indicated that a short wave radio transmitter, kindly lent by the Navy Office, had been installed at Mount Stromlo for this purpose. During the year, however, it was found that this method was somewhat limited in its application, and that two-way communication would be much more effective. Such inter-communication has now been rendered possible through the generosity of the Royal Australian Air Force, which has arranged to make available its spare transmitter on occasions, and also by the Postmaster-General's Department which from time to time places the investigators in telephonic communication. In this way the observers are able to exchange their observations at once, to plot them, and to discuss their results within a very short time of the actual period of observation.

The observations themselves have been continued throughout practically the whole of the period under review. In the early part of the year one of the Board's investigators (Dr. Huxley) was located at Mount Stromlo, but the authorities of the Observatory have now taken over the work and have arranged for one of their officers (Mr. Higgs) to co-operate with the Board's investigator at Laverton (Mr. Munro).

The investigations have, up to the present time, been mostly conducted by day. Some interesting results have been obtained, and are now being written up in report form for publication. It has been found that practically all the atmospherics observed in Eastern Australia by day on wave-lengths of 3,000 metres or less are due to thunderstorms occurring within

1,500 miles of the observing stations, and that these occur mainly in the afternoon and evening. Atmospherics are particularly prevalent in the inland areas of Queensland and New South Wales in the summer, while in the winter months they are much fewer and more scattered in their places of occurrence. These conditions are obviously in accordance with the usual meteorological conditions of summer and winter. As a matter of fact, the investigations have all through given no indication that conditions in Australia are any different from those of other countries, where it has been found that atmospherics are closely associated with the advancing edge of cyclonic disturbances and low-pressure areas; in other words with thunder or rain storm areas. The system has been particularly effective in tracing these disturbances across the Tasman Sea. The work is thus demonstrating the value to Australia of the use of cathode ray direction finders for long range weather forecasting, and in connexion with the following of thunderstorms with a view to warning aircraft.

Another point brought out by the work is that atmospherics arising in Australia do not vary much in size at their origin, and it is thus possible for even one investigator unaided to find their approximate source from their direction and size alone. This applies in particular to observations on 3,000 metres.

At night, the atmospherics observed may come from much further off, particularly those on long wave-lengths such as 30,000 metres. At this frequency they may come from the other side of the world. The atmospherics recorder at Mount Stromlo has recently been adapted for the purpose of making continuous records of their direction of arrival.

It will be seen that much of the work of the Board in regard to atmospherics has been carried out on the wave-lengths of 3,000 and 30,000 metres, as these long waves are most suitable for direction finding and the location of the sources. With the knowledge so gained, the work can readily be extended to the shorter waves of the broadcasting band, which extension is now being undertaken.

Investigations at Watheroo.—The old type atmospherics recorder previously located at the Carnegie Institution's Magnetic Observatory at Watheroo has now been re-modelled and converted into a modern type.

5. Research Laboratory, Postmaster-General's Department.

In conformity with the practice adopted in previous reports, some notes dealing with the research activities of the Postmaster-General's Department are included. These investigations are carried out quite independently to those of the Board.

Standard of Frequency.—A multi-vibrator standard of frequency has been set up in the laboratory. It has been used extensively for checking the frequency of broadcasting stations throughout the Commonwealth, and has been invaluable in ensuring that the various stations are operating on their allotted channel.

Audio Frequency Amplifying Equipment.—Particular attention has been given to the design and performance of the audio frequency amplifying equipment normally associated with radio broadcasting services. In particular, a careful check has been kept to ensure that satisfactory operation is obtained from microphone and programme line amplifiers. With the latter equipment it has been possible to predict and establish the voice frequency levels which give the best conditions for any given programme channel. Equipment has been developed to assist in maintaining these levels under plant operating conditions.

Performance of Radio Transmitters.—Apparatus has been designed to permit of a better standard of performance being maintained at broadcasting stations. Such equipment provides for regular checks being made on the overall frequency response of a complete transmitter, measuring of depth of modulation, measurement of unmodulated power in the aerial, and of peak voltages.

Response Measurement on Commercial Radio Receivers.—Further tests were made to determine the fidelity of response, the sensitivity, and selectivity of commercial radio receivers.

Interference to Radio Reception from local Electrical Disturbances other than Atmospherics.—The various means of reducing electro-magnetic radiation from electrical systems have been examined, and instructions have been prepared and issued to assist in locating and removing the source of the disturbances. Numerous cases throughout the Commonwealth have been investigated on the spot, and in practically all instances the disturbing source has been located and remedial measures effected, which have resulted in the suppression of interfering radiations.

6. Publications.

The following publication has been made as a result of the Board's investigations :—

Bulletin 47. Radio Research Board : Report No. 1.

1. Corrections to Field Strength Measurements with Loop Antennae, by W. G. Baker, B.Sc., B.E., and L. G. H. Huxley, M.A., D.Phil. (Oxon.). 2. A Radio Field Strength Survey within 100 miles of Sydney, by W. G. Baker, B.Sc., B.E., and O. O. Pulley, B.Sc., B.E.

Reports for publication are now in course of preparation in connexion with the following subjects :—

Work carried out at Jervis Bay in connexion with the Heaviside layer, by A. L. Green.

Devices for the Elimination of Fading, by W. G. Baker and A. L. Green.

Observations on the Interference of Sky Waves, by R. O. Cherry.

A Study of Atmospherics in Australia, by G. H. Munro, L. G. H. Huxley, and J. L. Pawsey.

7. Acknowledgments.

Once again, acknowledgment is due to a number of organizations and individuals for the valuable co-operation they have furnished. The help of the Postmaster-General's Department and the Universities of Melbourne and Sydney has been continued on the previous lines. The Department of Defence has afforded valuable assistance in several ways, but notably by the loan of apparatus and the accommodation of equipment (at Laverton (Victoria) and Liverpool (New South Wales)). The Commonwealth Solar Observatory at Mount Stromlo and the Watheroo Magnetic Observatory of the Carnegie Institution are also co-operating most helpfully in connexion with the work on atmospherics. Finally, during the period under review, the British Radio Research Board completed the last item of the Board's major equipment, namely an atmospherics recorder.

(See page 201 for descriptive matter.)

The F. D. McMaster Animal Health Laboratory.

Block kindly lent by the proprietors of the "Herald" newspaper, Melbourne.]

PLATE 1.

PLATE 2.

(The Rate of Growth of a South Australian Merino Fleece.)

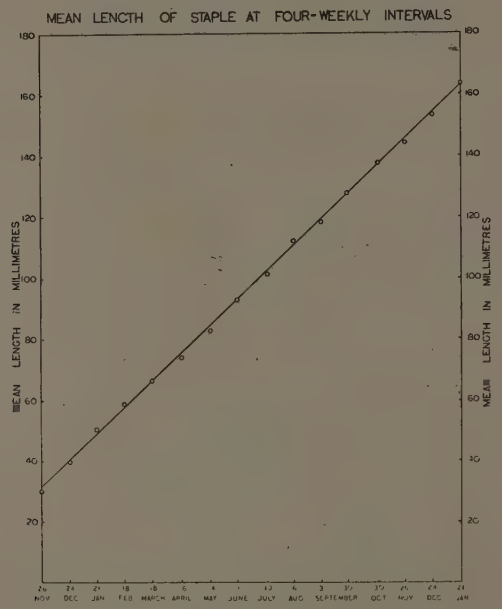


FIG. 1.—Graph showing the mean length of staple at monthly intervals.

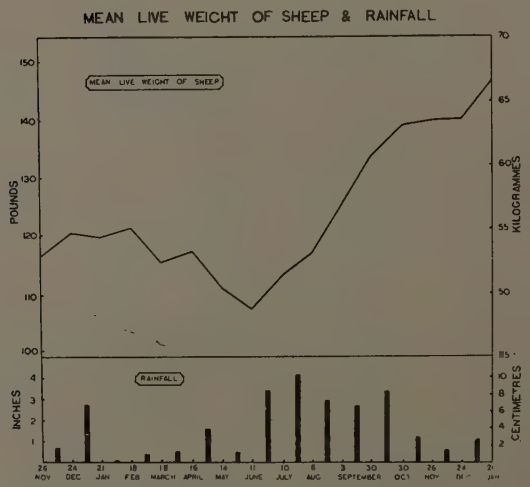


FIG 2.—Graph showing the mean live weight of sheep in relation to rainfall.

PLATE 3.

(The Relation between Durability and the Extractives of the Cypress Pines (*Callitris* sp.). See page 208.)

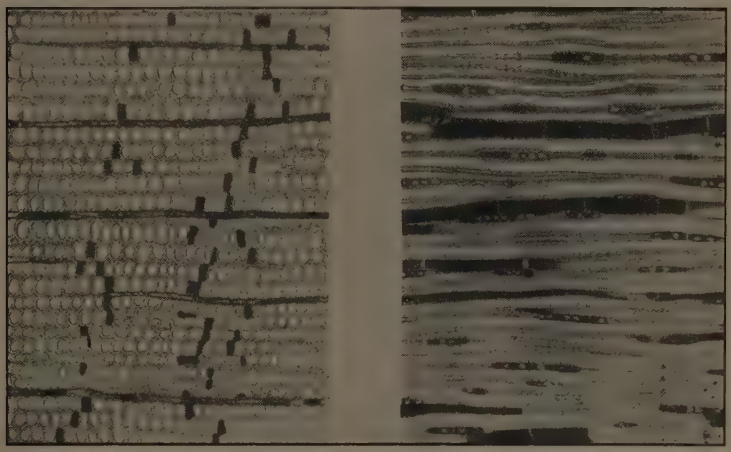
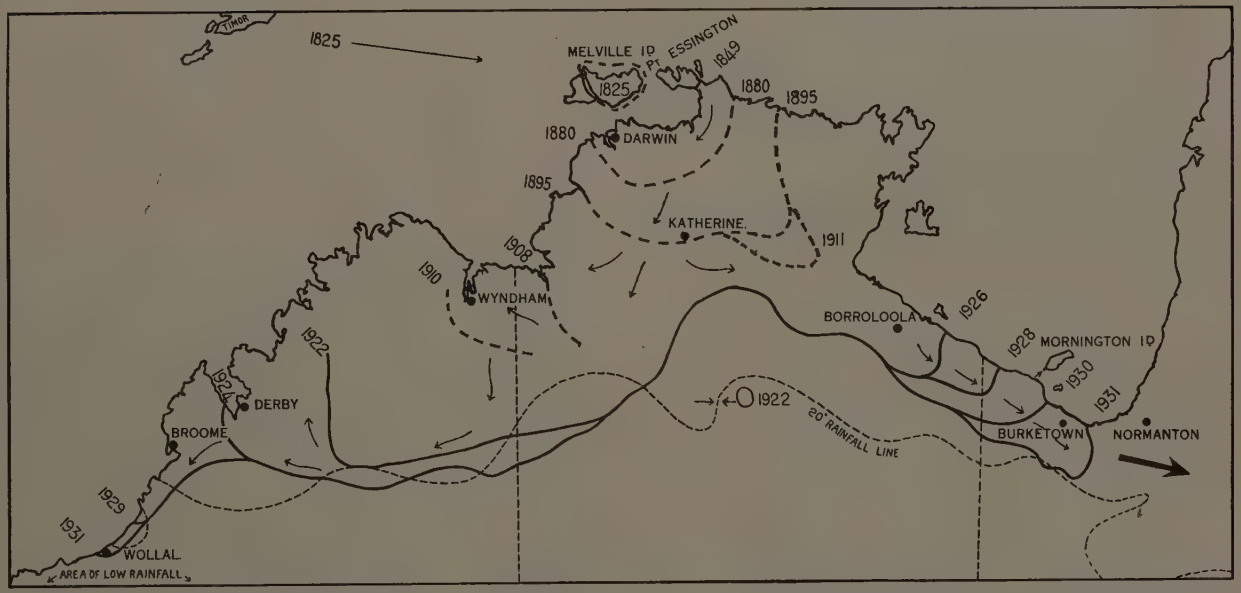


FIG. 1.—A cross section (left) and a tangential section (right) of the wood of *Callitris glauca*, showing the extraneous materials (the dark areas in the photographs) in the medullary rays and in the parenchyma tissue. These extraneous materials are responsible for the durability of this species. × 75.

(*Sarcostemma australe* (Caustic Vine): A Plant that is Poisonous to Stock. See page 225.)

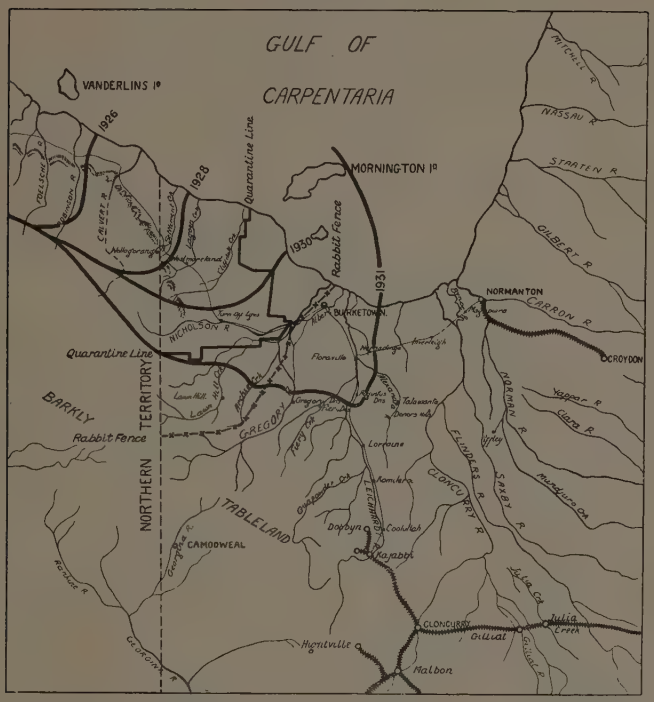
FIG. 2.—A photograph of the Caustic Vine (*Sarcostemma australe*) showing its characteristic habit of climbing into trees.

(The Buffalo-fly in Australia. See page 234.)



MAP 1.—Map of the area of infestation of Australia by Buffalo-fly. The thick black lines indicate the limits of the spread of the fly in the years stated. For the early years the lines are broken, to indicate that a little uncertainty exists as to their correct position.

PLATE 4.



Map 2.—Area of North-west Queensland invaded by Buffalo-fly. The limits of spread from the years 1926 to 1931 are indicated by the continuous thick black lines; the quarantine line by the continuous thick black line angulated; the rabbit-proof fence by the broken line; and railway lines by a thick black line with cross hatching.

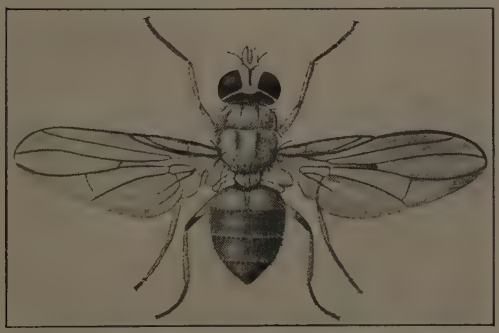


Fig. 1.
The adult Buffalo-fly.
× 12.

(*From Patton & Cragg, "Medical Entomology."*)

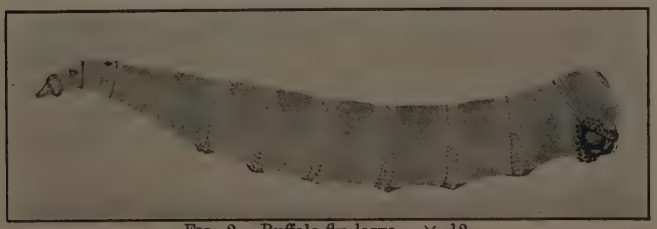


Fig. 2.—Buffalo-fly larva. × 12.

MAP. 3.—Map of Australia showing (a) present extent of area of infestation by Buffalo-fly (with close vertical shading), (b) potential area of infestation (with wider horizontal shading), and (c) density of cattle population indicated by dots. Each dot represents 2,500 head of cattle.
Based on a map in "Commonwealth Year Book," 1928.]

NOTES.

Investigations on Cheese Problems.

The Empire Marketing Board has approved of grants to the University of British Columbia for research on cheese-ripening processes, and to the New Zealand Dairy Research Institute at Palmerston North for investigation of the problem of "openness" in cheese. The work in British Columbia is being carried out under the direction of Professor Wilfrid Sadler, and the grant is a maximum of £1,900 spread over a period of three years, which sum is matched by the University of British Columbia. The grant to New Zealand is a maximum of £500 on account of capital, and £2,000 per annum for four years for maintenance, and is administered by the New Zealand Department for Scientific and Industrial Research.

The grant to the University of British Columbia has been made for the purpose of enabling researches into ripening of cheese to be pursued and to be developed. For some years, a study of the ripening processes of Kingston cheese has been in progress. Automatically, the work embraces a study of the ripening of Cheshire cheese as well, since it was from Cheshire cheese that the Kingston cheese was evolved in 1911. The Kingston cheese ripens very quickly; and, if the explanation of this phenomenon can be arrived at, it can be conjectured that the findings can be applied in the study of Cheshire cheese ripening and in that of other hard-pressed cheeses which are distinct and characteristic in type. Within reasonable limits, the broad principles which may be established from these researches can be applied equally well to the work in other countries. The principal objects of the investigations in Canada are to obviate difficulties which have arisen owing to complaints having been made about the open texture of New Zealand cheese. This openness takes the form of holes in the body of the cheese varying in type and distribution. Some types are present from the time of manufacture, others arise in the course of curing, and still others after the cheese has been cut. All of these are objectionable to the trade and consumer. At the present time, the position is such that the defect is coming to be recognized as a characteristic of New Zealand cheese. It is not new to the industry, either in New Zealand or elsewhere, but within recent years it appears to have increased in New Zealand produce. No definite reason can yet be attributed to this, for a number of interesting circumstances have played a part in the development of the New Zealand cheese industry. The problem of eliminating openness is of Empire significance, because it occurs in cheese from Australia, Canada, and the United Kingdom.

In accordance with its policy of promoting co-operation in schemes of research, the Empire Marketing Board has furnished particulars of these investigations to the Council for Scientific and Industrial Research. Professor Sadler and the Secretary of the New Zealand Department for Scientific and Industrial Research have both been requested by the Board to arrange for the supply of information to the Council as to the progress of the research, and already an interesting statement on the matter has been received from the former.

The Underground Grass-grub in Victoria and Tasmania—a Possible Parasite.

The Council's Division of Economic Entomology has recently received a supply of a parasite from the Cawthron Institute, New Zealand, which may possibly be of some use in connexion with the underground grass-grub of Victoria and Tasmania. An account of this grub and of the damage caused to pastures as a result of its attacks was given in the Council's Pamphlet 11, published in 1929.

The New Zealand parasite is a harmless, bright-brown fly, known as *Hystricia lupina*. It has been extremely common in New Zealand ever since settlement began, and has never in any way proved to be of the slightest danger to any economic plant or economic insect. It comes out in swarms in November each year, and sits about on shrubs and hedges, never entering houses or behaving obnoxiously in any way. It is a parasite of the New Zealand underground grub of the genus *Porina* which is closely allied to the genus *Oncopera*, the genus to which the Australian pest belongs.

The female fly lives for as long as two months. It does not lay eggs but deposits living larvae which are laid on areas of turf infested by subterranean grass-grubs. The young larva is very active, and on finding a burrow of a grub, proceeds to the bottom and then bores into the grub, which it eventually destroys in the chrysalis stage.

It is proposed to establish a colony of *Oncopera* in one of the Division's insectaries at Canberra, and to study the effect of *Hystricia* and any special points regarding the method of parasitism.

It is much too early to say whether this new parasite will be effective against the Australian variety of underground grass-grub, but the work now in progress at Canberra should soon place the Division in a position to give a more authoritative opinion on this point than is possible at the present time.

Experiments on the Storage of Passion Fruit.

Passion fruit of excellent quality is grown in every State of Australia, with the exception of Tasmania. Moreover, it if were possible to export the fruit on a commercial scale, there is little doubt that the production could be greatly increased.

During the current season, some preliminary experiments designed to study the conditions of treatment and cold storage necessary for successful transport overseas were accordingly commenced by the Council's Section of Food Preservation.

Preliminary inquiries showed that fungal attack and withering of the fruit were likely to be the chief causes of wastage during storage. Since the methods of washing citrus fruits with solutions of sodium bicarbonate and coating them with a layer of paraffin wax have been shown to reduce the wastage during storage,* it was decided to apply these methods to passion fruit. The effects of different wrapping materials were also tried. The fruit treated in these various ways was then stored in space kindly made available by the Victorian Department of Agriculture at its Victoria Dock Cool Stores.

It was impossible to begin the investigations until late in the Victorian season, but sufficient data, relating chiefly to the efficiency of the wrapping materials and to the efficacy of the washing and spraying treatment, have been obtained to guide future experiments.

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* *Jour. Coun. Sci. Ind. Res., Aust.*, 3 : 69, 1930.

Investigation on Bees.

For a number of years past, bee-keepers in Australia, and particularly those in the south, have been troubled by the so-called " disappearing trick " or the tendency of their hives to dwindle away. In some seasons, the losses involved are severe, often involving the majority of the hives.

The trouble appears to be connected with some pollen deficiency of the eucalypts, from which the bulk of the Australian honey production is obtained. It is well known that the eucalypts do not all flower annually, and that some varieties from which good honey is obtained, flower every two years only. The problem may arise owing to that reason. The fact remains that in bad seasons and in the absence of pollen in the dry months of January and March, no brood can be produced, and the hives dwindle away. Various pollen substitutes, such as rye flour, pea flour, dried milk, yeast, &c., have been tried, but with little success.

The Australian bee industry is responsible for a production worth £100,000 p. a. based on official statistics alone. Apiarists' associations, however, point out that the industry is worth very much more than this, as there is a large number of bee-keepers holding relatively small areas from whom statistical returns are not obtained. It would also appear that the industry is capable of considerable expansion if certain present disabilities, including the above-mentioned dwindling problem, can be overcome.

In the middle of the year 1930, the Victorian Apiarists' Association approached the Directors of the Rural Credits Development Fund of the Commonwealth Bank. As a result, the Fund made a sum of £1,000 available to the Council (for Scientific and Industrial Research) in order that the latter might carry out an investigation into the problem. The Directors have also indicated that, provided evidence of the usefulness and wisdom of work in this connexion is forthcoming, they would be prepared to consider providing some further sums towards the objective of a more complete research.

The season 1930–31 was an unfavourable one from the research point of view, as the trouble was not very much in evidence. Active investigations, however, have recently been initiated according to the initial scheme. Mr. G. A. Currie, of the Council's Division of Economic Entomology, will carry out the main fundamental work involved. This will be done at Canberra, and will consist of an attempt to find a pollen substitute with the following qualities :—(i) a mechanical condition like pollen so that the bees will collect it and store it in their combs ; (ii) chemically made up so that it will produce a full development of the pharyngeal glands (brood food glands) of the young worker bees so that they can produce the " royal jelly " with which the young larvae are fed during the first two and a half days of their lives ; and (iii) of such a quality that when fed mixed with honey to the older larvae it will produce normal development to the adult stage.

In addition, Mr. F. R. Beuhne, who was for many years Apiculturist to the Victorian Department of Agriculture, and who has been a bee-keeper for some 40 years, is assisting in connexion with certain aspects of the investigation in Victoria.

An Insect Pest of Pine Trees—the Pine Aphis.

In some places in Australia, recent plantings of pines have been followed by rather severe attacks by an insect which is almost certainly *Chermes pini*.

In Europe, damage caused to pines by this insect is negligible and, in fact, the insect is usually found in small colonies only, hiding under limited

areas of scaly bark. This is partly due to the severe weather conditions it experiences and partly to the action of other insects which keep it in check. In Australia, however, present indications are that the insect is liable to be present in greater numbers, and in certain places it may even reach pest proportions. There are reasons to believe that the pest has been brought out to this country without the full insect fauna by which it is kept down in other lands. At first sight, therefore, any Australian trouble that might reach serious proportions would quite possibly be solved by control measures of a biological nature, namely the introduction of predators and parasites which would attack the insect causing such trouble.

The Chief of the Division of Economic Entomology (Dr. Tillyard) has accordingly been giving some attention to this matter. At the present time, the insect concerned is being studied with a view to determining its identity with certainty, and in the meantime inquiries are being made in England as to the possible whereabouts of likely parasites. As a matter of fact, it so happens that Dr. A. J. Nicholson, who is a member of the staff of the Division, studied *Chermes pini* when he was at Birmingham University many years ago. It seems that the position is promising as regards biological control. There are a predatory lace-wing larva (*Hemerobius pini*), the larva of a species of *Leucopis*, and also the carnivorous larvae of several species of gall-midges or Cecidomyiidae. In addition, certain species of ladybird beetles and syrphid flies may be of importance.

Arrangements have now been made for the work on the pine aphis to be carried out in co-operation with the New South Wales Department of Agriculture. The New South Wales Forestry Commission is also providing valuable assistance.

The Small Lung Worm of Sheep in New South Wales.

By I. Clunies Ross, D.V.Sc., McMaster Animal Health Laboratory.

It appears to have been assumed that, in Australia, as in other parts of the world, the small lung worm of sheep is commonly *Protostrongylus rufescens* Kamensky, 1905 (syn. *Synthetocaulus rufescens*). Cameron* has shown that, in the British Isles, what was commonly thought to be *Protostrongylus rufescens* is in fact *Muellerius capillaris* (Mueller, 1899). Recently the writer has found larvae of either *P. rufescens* or *M. capillaris* in sheep from Tasmania, Victoria, and New South Wales, but has not had the opportunity, until the present time, of conducting a detailed post mortem of one of these animals. In one such animal, however, recently autopsied, typical lesions of small lung worm infestation were found in both lungs, and, on scrapings being taken from the bronchioles and lung tissue, considerable numbers of the typical larvae were found. After considerable search by the writer and Mr. H. Gordon, Walter and Eliza Hall Veterinary Research Fellow, a specimen of a male *M. capillaris* was found. The parasite may be easily distinguished from *P. rufescens* by the fact that no bursa copulatrix is present in the male.

It appears, therefore, that, in New South Wales, *M. capillaris* has been mistaken for *P. rufescens* in the past, though it is possible that both species occur here. It would be of interest if those interested in parasitology in this country would make a careful determination of any small lung worms found, in order to show the relative importance of the two species. *M. capillaris* is considered to be of considerable importance in the British Isles as a cause of verminous pneumonia.

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* *Jour. Helmin* (5): 1, 1-211, 1927.

The recent work of Hobmaier, A. and M.,* showing that the life cycle of *M. capillaris* involves the passage through a snail intermediate host, adds increasing interest to this question. It is hoped to devote attention to the life cycle of this parasite in Australia shortly. It may then be possible to suggest control measures, but at the present time none have been discovered.

Paralysis in Pigs - Report by Dr. Carr-Fraser.

Some years ago the Council had an officer—Dr. W. A. Carr-Fraser—engaged on an investigation into the paralysis of pigs. The work was carried out at the Glenfield Research Station of the New South Wales Department of Agriculture under the supervision of the Director of the Station, Dr. H. R. Seddon. Prior to Dr. Fraser reaching Glenfield, the staff there had already commenced some work on the problem, the results of which they made freely available to him.

Shortly afterwards, Dr. Fraser was appointed to a research studentship under the Science and Industry Endowment Fund, and left for England via the United States. After spending some two years at the Rowett Research Institute, Aberdeen, and obtaining the degree of D.Sc. in the Aberdeen University, with which the Rowett Institute is closely associated, he has now returned to Australia, and is located at the Council's F. D. McMaster Laboratory.

The object of his visit to America was to collect as much information as possible regarding a condition of pigs which seemed to be similar to the Australian trouble. He has now furnished a report of his inquiries, the conclusions of which read as follows :—

(1) The published reports of the investigations conducted in the United States of America upon the locomotory abnormalities in pigs, either induced by experimental means or occurring in pig herds, give information upon a syndrome which is dissimilar to the locomotory syndrome found to develop under natural conditions in pigs in the States of the Australian Commonwealth, and which has formed the subject of an investigation by the Council.

(2) No attempt has been made by the investigators in the United States to differentiate between the specific and non-specific locomotory syndromes that may arise in pigs from a multiplicity of causes.

(3) Success in the prophylaxis, and therapeutic treatment of many, but not all, cases of non-specific locomotory disturbances occurring in pigs in the United States, based as it is upon similar experimental evidence from various sources, is the strongest argument in favour of the contention that the causation of these conditions has been proved to be primarily associated with the mineral content of the rations and factors concerned with the assimilation of certain mineral essentials. The problem is no longer receiving great attention from investigators.

(4) There does occur, in the State of Minnesota, a locomotory disturbance affecting pigs of similar age and under similar conditions which bears so close a resemblance in symptomatology and macroscopic pathology to the naturally occurring condition in Australia, that the two conditions cannot be differentiated. Its occurrence is apparently vary rare, and hence is of no economic importance.

* *Munch. Tier. Woch* (80 : Nr. 36, 1929.

A New Journal—The "Veterinary Bulletin."

In the previous issue mention was made in regard to the new Journal, *Nutrition Abstracts and Reviews*, of the importance of abstracting Journals covering the various branches of agricultural science, and of the emphasis laid on this matter by the 1927 Imperial Agricultural Research Conference. In so far as animal health is concerned, the Imperial Bureau of Animal Health is now issuing a new periodical known as *The Veterinary Bulletin*. Arrangements have been made with the Bureau of Hygiene and Tropical Diseases whereby the publication of the *Tropical Veterinary Bulletin* has been discontinued with its number of December, 1930, with the idea that its place will in future be taken by the *Veterinary Bulletin*.

The latter will deal with all aspects of animal health, in so far as they relate to original research and to administrative control, but it will not deal with clinical material from the point of view of the practitioner. The ground covered by the *Tropical Veterinary Bulletin* will be included, and, in addition, the diseases of temperate climates will be given full consideration. The subjects dealt with will be classified under the following headings :—Diseases caused by bacteria and fungi, protozoan parasites, filtrable viruses and metazoan parasites, diseases in general, diseases related to nutritional, metabolic, and genetical factors, invertebrate vectors of disease, public health, mineral and plant poisoning, specific drug therapy, miscellaneous, official and other reports, and book reviews.

The Bulletin will be of crown quarto size, 9¾ in. x 7½ in., and Volume I. will run to about 384 pages, including the index. The four parts of Volume I. are being issued on 1st April, 1st July, 1st October, and 1st December respectively. The subscription will be £1 per volume or 7s. 6d. per copy. From 1st January, 1932, the journal will be published monthly, and the volume will run to about 600 pages, including the index.

Subscriptions to the *Veterinary Bulletin* are invited, and should be sent to the Imperial Bureau of Animal Health, Veterinary Laboratory, Ministry of Agriculture and Fisheries, Weybridge, Surrey, England.

A New Journal—"Herbage Abstracts."

The Imperial Bureau of Plant Genetics (Herbage Plants) is issuing a new journal, *Herbage Abstracts*, with a similar object in view to that of the above-mentioned *Veterinary Bulletin*.

Herbage Abstracts will deal with herbage and certain forage crops not only from the point of view of the plant breeder, but also from that of the agronomist. Such subjects as field trials, seed production, weed control, and also grassland and pasture management will be dealt with rather fully, while information regarding morphology, physiology, ecology, &c., will be introduced when it is considered desirable. Each number will also contain a section of miscellaneous notes, short abstracts from official reports, and proceedings of conference which might be of value to the worker on herbage and forage crops and general grass land.

At present, the majority of the papers and reports abstracted deal with the more temperate regions, but as the study of tropical grassland and forage crops develops it should be possible to supply more information for such conditions.

The subscription to the journal (which is a quarterly) is 1s. 6d. per copy or 4s. for the 1931 set (three issues only), and thereafter 5s. per annum. Subscriptions are invited from anyone who may be interested, and should be sent to the Imperial Bureau of Plant Genetics : Herbage Plants, Agricultural Buildings, Aberystwyth, Wales.

Pastures: Visit of Mr. W. Davies to Australia.

Mr. W. Davies, of the Plant Breeding Research Station at Aberystwyth, Wales—which specializes in the breeding of grasses—will reach Australia early in November on a twelve months visit. The object of this visit is in order that he may discuss pasture problems and grassland management with local authorities, and give the benefit of his advice in that connexion. A year or so ago he made a very similar visit to New Zealand.

He is coming to Australia as a result of representations made by the Australian Dairy Council. A little time ago this body, through the London agency of the Dairy Produce Control Board, approached the Empire Marketing Board with a request that it should finance a visit to Australia of Mr. Davies. The Board received the request sympathetically and has agreed to finance the present visit, the Dairy Council meeting special expenses that will be involved to the extent of £200.

The Dairy Council subsequently asked that the Council for Scientific and Industrial Research should make the detailed arrangements for the visit in co-operation and collaboration with the various State Departments of Agriculture. This has now been done. As a result, it is being suggested to Mr. Davies that he should remain in Western Australia to the 18th November, in South Australia to the 9th December, in Tasmania to the 31st December, in Victoria to the 31st December, in New South Wales to the 7th March, and in Queensland until the 8th April. Detailed itineraries within the respective States have also been prepared.

By the termination of the above period, there will have been ample opportunity for Mr. Davies, in consultation with the various persons concerned, to have thoroughly discussed various matters, and thus to make suitable arrangements for the completion of his work during the remainder of his twelve months' visit. He is expected to reach Fremantle on the 2nd November, 1931.

Braxy-like Disease of Sheep (Infectious Entero-Toxaemia) in Western Australia.

In the previous issue, a short note appeared (on page 190) in regard to the investigation of the above disease which is being carried out by the Council and the Western Australian Department of Agriculture in co-operation.

An article, couched in non-scientific language, and describing the disease, its cause, incidence and practicable methods of control, has now been printed in the Department's Journal for September, 1931. The Council has a small supply of reprints of this article and a copy would be sent to any one interested. Of late, several indications have been obtained that infectious entero-toxaemia occurs to some extent in the Eastern States where its presence may have been formerly masked by the much more common complaint, namely, black disease.

The Bermuda Marine Biological Station.

The Empire Marketing Board has made a grant of £2,500 to the Bermuda Marine Biological Research Station. Bermuda has been the seat of a small biological research station for the past 25 years. During

this period, it has been under American direction, and with the small means at its disposal it has been able to demonstrate the opportunities afforded by Bermuda for marine research. The Trustees of the Rockefeller Foundation have contributed £50,000 towards the station with the special purpose of developing large scale oceanographical investigations to be linked up with corresponding investigations to be conducted from the newly-founded Woods Hole Oceanographical Institution for the establishment of which the Rockefeller Trustees are also mainly responsible. The Government of Bermuda has provided a site of 12½ acres for the Station, and is making an annual grant of £200 for ten years towards its maintenance.

The Trustees appointed include three British experts, Dr. A. G. Huntsman of Canada, Professor J. R. Ashworth, University of Edinburgh, and Dr. E. J. Allen, Director of the Marine Biological Research Station, Plymouth. From an oceanographical point of view, Bermuda is situated in the best position for a regular and systematic study of the waters of the North Atlantic the movements of which, and particularly of the Gulf Stream, have a fundamental effect upon the fisheries exploited by fishermen in the British Isles, as well as by those off the Atlantic coasts of Canada and Newfoundland. It is generally agreed that definite knowledge regarding the problem of the fluctuations in the fisheries on both sides of the Atlantic cannot be obtained until much more is known about the general circulation of the Atlantic and its variations from season to season and from year to year.

Meeting of the Full Council.

A meeting of the full Council (for Scientific and Industrial Research) was held in Melbourne during the latter part of August last. The main purpose of the meeting was to discuss the annual reports that had been furnished by the Chiefs of the various Divisions, and by the officers in charge of outside investigations, and in general to review the progress made. Much of the information given in these reports will be contained in the forthcoming annual report of the Council as a whole, but it is also proposed to enlarge on such information in future issues of the Journal.

Considerable attention was given by the Council to financial matters and to the funds that could well be spent on its researches with every prospect of large national dividends. In that connexion, the following resolution was carried:—

> "This Council expresses its appreciation of the financial support given by the Commonwealth Government to the work of the Council in a time of financial stress, of the generous gifts of money and material provided from outside sources (particularly the Empire Marketing Board and the Rural Credits Development Fund of the Commonwealth Bank) and of the valuable co-operative assistance given by Government Departments, Universities, and other institutions. It reiterates the belief that a country like Australia, which is dependent for its prosperity to such an extent on the welfare of its primary industries, must look to an increasing degree to scientific research to overcome many of the problems with which these industries—and particularly the pastoral and agricultural industries—are faced, and thus to help to place them on a more secure basis."

Recent Publications of the Council.

Since the last issue of the *Journal*, the following Bulletins and Pamphlets have been published :—

Bulletin No. 51—" A Soil Survey of the Soils of the Lower Murray River," by J. K. Taylor, B.A., M.Sc., and H. G. Poole, M.Sc.

In this publication, the results of a soil survey of about 13,000 acres of swamp land along the Lower Murray River between Mannum and Wellington are given. Five detailed maps of the individual areas are also included as folders. The survey leads to the conclusion that considerable further development is possible by improvement of the herds and of farming methods, and by improvement of the pastures. In the latter connexion, the present tendency to change from lucerne to permanent pasture is regarded as significant. Field experiments on liming and on the effects of phosphatic and nitrogenous fertilizers are considered desirable.

Bulletin No. 52—" The Soils of Australia in relation to Vegetation and Climate," by J. A. Prescott, M.Sc.

The principles of soil classification, based on a study of the soil profile, are examined in the light of the distribution of the major groups of Australian soil types and of the corresponding vegetation associations. The survey records and ecological literature of Australia have been examined with a view to defining, mapping, and correlating the major vegetation associations and soil groups.

The following vegetation associations are recognised :—Desert grass (porcupine grass) on sandhills; desert scrub, characterized by acacias, mulga, myall, and gidgea; shrub steppes of saltbush and bluebush; savannahs and Mitchell grass downs; savannah woodlands; Mallee scrub and sclerophyll woodlands; brigalow scrub; sclerophyll forests; mountain grasslands and high moors; and heath and sclerophyll scrub.

The soil groups proposed include :—Desert soils and semi-desert soils of sandhills, gibber and gravel plains and stony surfaces; Mallee soils, calcareous, somewhat saline and weakly solonized; red-brown earths, weakly podsolized surface with calcium carbonate in deeper horizons; black earths, mainly heavy soils in eastern Australia; grey and brown soils, principally heavy soils in the semi-arid zone; podsolized soils in regions of higher rainfall under sclerophyll forests; red loams mainly derived from deeply weathered basalts; high moor; lateritic sand plains, presumed to be ancient podsols.

A folding soil map of Australia and a larger folding coloured vegetation map of the Continent are included in the Bulletin.

Pamphlet No. 22—" The Chemistry of Australian Timbers: Part I. A Study of the Lignin Determination," by W. E. Cohen, B.Sc., and H. E. Dadswell, M.Sc.

This publication deals with the proper sampling of wood for analysis and the accurate estimation of lignin. Methods for both of these have been standardized in the United States, but certain characteristics of Australian hardwoods have brought out what appear to be serious errors in the standard practices. In particular, it appears that, in the past, varying amounts of extraneous material have been determined as part of the lignin. The suggestion is made that wood be purified with weak caustic soda solutions, which remove this extraneous material, before the lignin is determined. The practical applications of the work concern timber identification, the manufacture of paper pulp, and other methods of utilizing timber.

Forthcoming Publications of the Council.

The following future publications of the Council are now in the press:—

Bulletin No. 53—"The Flying Fox (Pteropus) in Australia," by F. N. Ratcliffe, B.A.

Bulletin No. 54—"Investigations on 'Spotted Wilt' of Tomatoes—II.," by J. G. Bald, B.Agr.Sc., and Geoffrey Samuel, M.Sc.

Bulletin No. 55—"The Basal (Standard) Metabolism of the Australian Merino Sheep," by E. W. L. Lines, B.Sc., with the assistance of A. W. Peirce, B.Sc.

Bulletin No. —"Infectious Entero-toxaemia (so-called Braxy-like Disease) of Sheep of Western Australia," by H. W. Bennetts, D.V.Sc.

Bulletin No. —"The Ripening and Transport of Bananas in Australia," by W. J. Young, D.Sc., L. S. Bagster, D.Sc., W. Hicks, B.Sc., and F. E. Huelin, B.Sc., and in part by R. A. Holloway, B.Sc., B.E., and O. P. Barr, B.E., for the N.S.W. Railway Commissioners.

Bulletin No. —"A Soil Survey of Blocks A, B. C, D, and F, Renmark Irrigation District, South Australia," by T. J. Marshall, B.Sc. (Agr.) and P. D. Hooper.

Bulletin No. —"Studies in Supplementary Feeding of Merino Sheep for Wool Production," by Hedley R. Marston.

Bulletin No. —"The Life Cycle of *Stephanurus dentatus*, the Kidney Worm of Pigs," by I. Clunies Ross, D.V.Sc., and G. Kauzal, D.V.Sc.

Pamphlet No. —"The Irrigation of Horticultural Community Settlements," by A. V. Lyon, M.Agr.Sc.

Pamphlet No. —"Refrigeration applied to the Preservation and Transport of Foodstuffs," by J. R. Vickery, Ph.D.

Pamphlet No. —"Termites (White Ants) in South Eastern Australia," by G. F. Hill.

Pamphlet No. —"The Preservation of Fence Posts," by J. E. Cummins, M.Sc.

"Nutrition Abstracts and Reviews"—A New Periodical.

It is regretted that a slight error occurred in the last paragraph of the note that appeared under the above title in the previous issue. The subscription should have been indicated as £1 1s. per volume and not as £1.

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